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THE SARCOSTYLES OF THE PLUMULARIDÆ.[1]

C. C. NUTTING.

THERE is no little confusion regarding the nomenclature involved in morphological discussions concerning the Hydroida, and nowhere is this fact more evident than in connection with certain interesting structures found in the Plumularidæ and variously called nematophores, protoplasmic processes, defensive zooids, sarcodal processes, Machopolyps, "Wehrthiere," and Nesselpolypen by the numerous writers who have investigated them. The first mention that I have been able to find of these structures is by Busk in Hunterian Lectures (MSS.), London, 1857, who called them "Nematophores," — a name subsequently used by various writers. Hincks afterward applied the name "sarcotheca" to the chitinous receptacle, and "sarcostyle" to the sarcodal contents, or rather defensive persons, inclosed within it. Without further discussion on this point, I will state that I use the word nematophore for the receptacle without necessary reference to its contents, and sarcostyle for the organ or person within, and it is to the latter that I invite attention at present.

[1] Read before section F at the Detroit meeting of the American Association for the Advancement of Science.

The hydroids have been carefully studied by so few zoologists that it may not be amiss to define the sarcostyle more explicitly before discussing it. A careful investigation of any plumularian hydroid will disclose the fact that beside the hydrothecæ containing the hydroid polyps or hydranths, there are numerous usually minute chitinous cups containing an exceedingly interesting structure, which in life is characterized by amazing extensibility. Allman in 1864 described it as "a soft granular mass which could send forth very extensible processes capable of being greatly protruded, and then so completely retracted as to apparently disappear. These processes have the power of sending forth pseudopodia, as does the amœba, and act in many respects as do certain rhizopods." This author considered that these processes were composed of protoplasm, pure and simple.

When, however, the more refined and modern histological technique was applied by Hamann to the investigation of the sarcostyles, it was discovered that they were much more complicated structures than was at first supposed; that they were made up of several histological elements; namely, an ectodermal layer surrounding an axial portion composed of endodermal cells, the ectoderm and endoderm being separated by a structureless membrane or "Stutzlamelle." The distal part of the sarcostyle contains nematocysts or nettling cells. This author (Hamann)[1] concluded that the enormous extensibility of the sarcostyle was due to muscle fibrillæ, and regards the entire sarcostyle as a degraded person or hydroid polyp in which the mouth and body cavity have been obliterated.

In the same year, 1882, C. de Merejkowsky[2] announced that the histological elements were ectoderm and endoderm with a dividing membrane, and that the motile part was composed of ectoderm alone, the ectodermal cells being *immersed in a contractile structureless protoplasm.* To this latter substance he attributed the enormous extensibility of the sarcostyle and the pseudopodia-like processes originally described by

[1] Der Organismus der Hydroidpolypen. *Jenaische Zeitsch. f. Naturw.*, Bd. xv, pp. 17, 18, 65.

[2] *Arch. de Zool. Exp. et Gen.*, vol. x, pp. 583–610.

Allman. This author regards the sarcostyles as degenerate individuals of the hydroid stock, serving the purpose of defensive organs and possibly also as aid in the nourishment of the colony.

Weismann, in his *Die Enstehung der Sexualzellen bei den Hydromedusen*, denies the presence of the interstitial protoplasm in the ectodermal portion and contends that the pseudopodia are from the ectoderm cells themselves.

In the same year, 1883, von Lendenfeld[1] made a very elaborate study of the sarcostyles. In addition to the ectoderm, endoderm, and "Stutzlamelle" already mentioned, he found a differentiated ectodermal muscle layer, in which are large ganglion cells in Plumularia. In certain species of Aglaophenia and Plumularia he found sarcostyles furnished with adhesive cells similar to those found in ctenophores, but differing from them in not having a spirally rolled thread.

Dr. Carl F. Jickeli[2] agrees with most of the other writers concerning the histology of these structures, but has a unique idea of their homology. He thinks that the sarcostyles are homologous with the capitate tentacles of many species of hydroid polyps. I believe that he has no supporters in this view.

No other investigations of sufficient importance to discuss in this connection have been made so far as I know, with the exception of my own work in 1895 at Plymouth, England,[3] and at Naples, where I made careful studies of these structures in the living plumularians and by means of serial sections.

The histology of the sarcostyles, as held by most of the above writers, shows an outer layer of ectoderm and an inner layer of endoderm, these two layers being separated by an apparently structureless membrane called by the German writers the "Stutzlamelle." The endodermal layer appears to be a solid core in stained and sectioned preparations, and is so described by most writers. Under favorable conditions living

[1] Ueber Wehrpolypen und Nesselzellen. *Zeit. f. wiss. Zool.*, Bd. xxxviii, pp. 355–371. [2] *Morphol. Jahrb.*, Bd. viii, pp. 580–680.

[3] See C. C. Nutting, Notes on Plymouth Hydroids. *Journ. Marine Biol Assoc.*, February, 1896, p. 153.

specimens may be examined under a high power, and by a proper management of light the cell boundaries, muscle, and indeed almost every histological detail may be distinctly seen and the movements followed. It was while making such examinations of living sarcostyles at Naples in 1895 that I found an unexpected proof that the axis of the sarcostyle is not a solid rod, but a delicate collapsible tube, the cavity of which is strictly homologous with the body cavity of the hydranth. While studying a living sarcostyle under a $\frac{1}{12}$ oil-immersion lens, the endodermal axis, as it is called, was very sharply defined, being separated from the ectodermal layer by the "Stutzlamelle." Much to my surprise, I saw an amœboid cell pass quickly along the exact center of the axis. The cell was largely composed of highly refractive granules and exhibited very active amœboid movements, sending forth well-marked pseudopodia and constantly changing form. This mysterious cell appeared to be engaged in traveling back and forth between the distal and proximal end of the axial cavity of the sarcostyle. Its progress was unimpeded and completely demonstrated to my mind the presence of an axial cavity in the sarcostyle. After having once seen this cell, I looked for them in other sarcostyles and found them in nearly every one examined. The species under observation was *Aglaophenia helleri.* I afterward found similar cells in the endoderm of various parts of the plumularian colony, particularly in the stem. In such localities, however, they did not move from place to place, but nevertheless sent forth numerous pseudopodia and exhibited amœboid change of form.

This demonstration of an axial cavity in the sarcostyle is of considerable interest, in view of the fact that it furnishes the last and much-desired link in the evidence needed to demonstrate the homology of the sarcostyle. It can no longer be doubted, it seems to me, that the sarcostyle is the homologue of the hydranth; that it is, in fact, a true "person" of the hydroid colony, being composed of ectoderm, "Stutzlamelle," endoderm, and body cavity. It lacks only tentacles to make it a hydranth, but we know that certain hydroids, *e.g.*, Protohydra, have undoubted hydranths without tentacles.

Curiously enough, one of the earliest observers of nematophores published in 1863 a figure of a sarcostyle which was represented as having a body cavity. The author referred to is Semper, and the figure is found in the *Zeitschrift für wiss. Zoologie*, Bd. xiii, Pl. XXXVIII, Fig. 4 *a*.

The conclusion that sarcostyles are morphological persons of the colony is borne out by almost every known fact concerning them. Embryological investigation shows that they are formed in almost exactly the same manner as the hydranths, and that they make their appearance as early as the latter and often earlier. It is possible, moreover, to point out a series of forms leading from the so-called "fighting zooids" of Hydractinia to the typical nematophores of the Plumularidæ. In the genus Ophiodes we find organs or persons almost exactly intermediate between the Hydractinia and true sarcostyles. Prof. Baldwin Spencer has lately described a new family of Hydroida, called the Hydroceratenidæ, evidently closely allied to the Plumularidæ, with numerous fighting persons which are histologically almost identical with true nematophores; the extreme extensibility, however, of the latter has not as yet been observed in the former.

There appears also to be a curious cross relation between the dactylozooids of the Millipora and the sarcostyles, if such they be, of the Hydroceratenidæ.

Among the many perplexing questions in this connection is the one raised by Professor Allman, who very strongly urges the relationship between the nematophores and the denticles of the graptolites. His argument would lead to a belief that the ancestors of the Plumularidæ may be the graptolites; that the nematophores of the former are the homologues of the denticles of the latter; that we have in the sarcostyle the original type of the hydranth; and that the present hydranth is really a very highly specialized sarcostyle.

As before indicated, the sarcostyles often precede the hydranths in the development of the colony, and would thus appear to be an older structure in phylogeny.

I was unable to confirm Merejkowsky's statement that the extensible part of the sarcostyle was composed of ectodermal cells immersed in free protoplasm. Indeed, it appears that no

other author has been able to demonstrate this certainly unique and surprising arrangement. Neither could I find the muscle bundles and ganglion cells of von Lendenfeld, although this purely negative evidence should not be allowed to have much weight. The adhesive cells were found in several species of Aglaophenia, and observed in action; the observations confirm very decidedly the description given by their original describer, von Lendenfeld.

There has been considerable discussion concerning the probable use of the sarcostyles. My own observations on the living organisms would indicate that they serve several distinct functions.

1st. *Defense.* In many cases, especially in the genera Aglaophenia, Lytocarpus, and Cladocarpus, the distal part of the sarcostyle contains a battery of very large and formidable nematocysts or stinging cells. The threads of these cells are projected all together when a large or dangerous enemy approaches too near the adjacent hydranth. It is probable that the cnidocils of these nematocysts must be touched before the battery is discharged. Some species of Lytocarpus have such effective batteries that their sting is severely felt through the human cuticle, a very unusual thing among the Hydroida. The nematocysts themselves do not leave the nematophores when their threads are projected.

2d. *Prehension of food.* This is effected by the adhesive cells, which are situated on the extensible part of the sarcostyles of many species. Von Lendenfeld gives an excellent description of the capture of small crustacean zoœa. From his account it appears that the prey is first paralyzed by the nematocysts in the tentacles of the hydranths, and then secured by the adhesive parts of the adjacent sarcostyles which stick firmly to the smooth chitinous covering of the crustacean. After this attachment is formed, the contraction of the sarcostyle brings the victim again within the reach of the tentacles, which convey it to the mouth of the hydranth.

3d. *The removal of refuse or decomposing organic matter.* This function of the sarcostyles has been suggested by several

writers. I have on many occasions noted that the sarcostyles are very active after certain parts of the colony have been mutilated or where the hydranths are undergoing disintegration. While studying *Plumularia pinnata* at Plymouth I saw astonishing exhibitions of activity on the part of the sarcostyles in the vicinity of mutilated gonangia. Their extensibility was incredible and apparently without limit. They would climb over the top of the gonangia and scour the inside, they would wind round and round the stem and branches in a perfect maze of apparently protoplasmic threads, and yet be able to unsnarl themselves with the greatest ease and afterward disappear entirely. Dead hydranths seemed particularly attractive to them, and it appeared as if they actually devoured or in some way absorbed the organic matter of the disintegrating polyps, so that not a trace remained within the hydrothecæ in a very short time after the sarcostyles attacked them.

4th. *Holding together adjacent corbula leaves until their edges unite.* This is a novel use of the sarcostyle, discovered by myself while working out the embryology of the corbula, or fruit receptacle, of *Aglaophenia pluma* at Plymouth. The corbula is a pod-shaped structure made up of a number of ribs or leaves, which are separated first, but afterward coalesce to form the mature corbula. Along the edges of these leaves are rows of nematophores.

While examining a young corbula of a living colony, I noticed that the sarcostyles along the edges of the leaves were exceedingly active and that they were stretching across from one leaf to the next, to which they adhered by their adhesive ends. "It appeared as if these sarcostyles served as a temporary attachment to hold the edges of the two leaves together, while the edges themselves were connected by trabeculæ of cœnosarc which rapidly formed a stronger and permanent connection. The perisarc of the edges of the leaves seemed exceedingly thin and in places appeared to be wanting. A contact having been established between the adjacent leaves, the permanent attachment was soon formed and the cœlomic cavities of the leaves established connections at these points.

A little later currents of water bearing granules were seen to flow in active streams from one leaf to the other."[1]

In this case it appeared as if the sarcostyles served to hold the edges of the leaves together while the permanent connection was being established, after which the sarcostyles loosened their hold and retracted into their respective nematophores.

[1] C. C. Nutting, Notes on Plymouth Hydroids. *Journ. Marine Biol. Assoc.*, February, 1896, p. 153.

THE WINGS OF INSECTS.

J. H. COMSTOCK AND J. G. NEEDHAM.

CHAPTER III.

The Specialization of Wings by Reduction.

I. INTRODUCTION.

THE recognition of certain features of the venation of the wings of insects which occur in the more generalized forms of a large proportion of the orders of this class has enabled us to present a hypothetical type to which the wings of all orders may be referred. A detailed discussion of the features of this

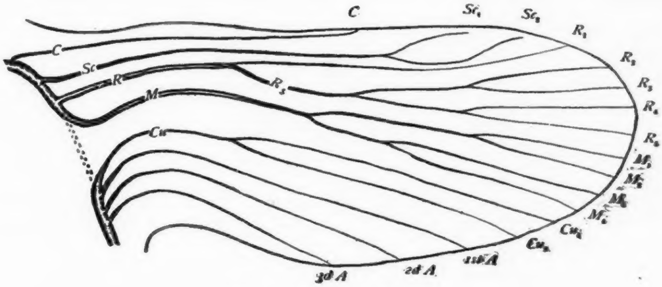


FIG. 5. — Hypothetical type.

type has already been given; the figure representing it is repeated here (Fig. 5) in order that it may be easily compared with figures of actual wings. It represents the supposed arrangement of the tracheæ in a wing of the nymph of the primitive winged insect. By omitting the basal part, the figure will also serve to show the number and arrangement of the longitudinal wing-veins of the adult.

It will be seen at a glance that this hypothetical type differs from the great majority of living insects in the possession of a larger number of wing-veins than is characteristic of them; it also differs, and in a more striking degree, from most of the

insects of the Linnean order Neuroptera in having a much smaller number of wing-veins than is possessed by them.

These differences indicate two different methods of specialization by which this primitive type has been modified: the one, specialization by reduction; the other, specialization by addition.

We postpone any farther reference to the latter method of specialization and confine our attention in this place to a study of some of those forms in which a tendency to modify the primitive type by a reduction in the number of wing-veins is evident.

A reduction in the number of wing-veins takes place in two ways: first, by atrophy of veins; second, by the coalescence of two or more adjacent veins.

The first method is illustrated in most of the orders where a reduction in the number of wing-veins has taken place by the atrophy, more or less complete, of one or more of the anal veins; this is correlated with a reduction in the extent of the anal area. This method is also illustrated in certain cases where there is no apparent reduction of the area of the wing from which the vein has disappeared. The most familiar illustrations of this occur in the Lepidoptera. In this order, as is well known, the main stem of the media disappears in many families; and in the geometrid moths of the family Eunomidæ, the second branch of this vein is also lost.

The second method of reduction — that is, by coalescence — takes place in all of the orders in which the number of wing-veins is less than in the typical wing. This also takes place in two ways: first, the point at which two veins separate occurs nearer and nearer the margin of the wing, until finally, when the margin is reached, a single vein remains where there were two before; second, the tips of two veins may approach each other on the margin of the wing until they unite, and then the coalescence proceeds towards the base of the wing. The former is a coalescence extending outward; the latter, a coalescence extending inward. Examples of the former are common in all of the orders discussed in this chapter; illustrations of the latter are most easily observed in the Diptera.

The typical arrangement of the wing-veins is often modified, also, by an anastomosis of two veins; that is, two veins will come together at some point more or less remote from their extremities and merge into one for a greater or less distance, while their extremities remain separate. This is illustrated in Nemoura (Fig. 8), where veins Sc_2 and R_1 anastomose.

In the preceding chapter we suggested a nomenclature of the principal wing-veins and of their chief branches, which is applicable to all of the orders of winged insects. At that time nothing was said regarding the cross-veins; for it seems hardly

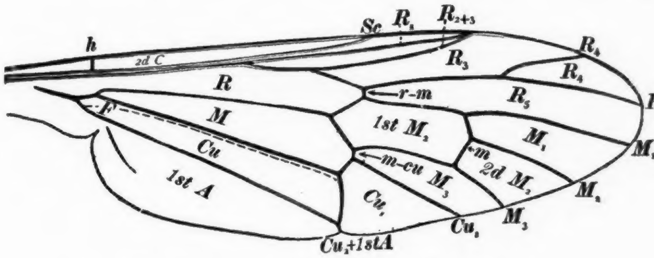


Fig. 6. — Wing of a Leptid, showing cross-veins and cells.

practicable to propose a nomenclature of these based on homologies which shall have an equally general application. This arises from the fact that in those orders where the number of wing-veins is greatly increased, the primitive cross-veins, if such exist, are in most cases indistinguishable from those that have been developed secondarily.

But when we examine the wings of those orders in which the tendency is towards a reduction in the number of wing-veins, we find that there are a few cross-veins which are so constant in their position and which occur in so many widely separated groups that they are evidently homologous. As the number of these is small, we propose to designate them by names, as follows:

The humeral cross-vein. This is a single cross-vein extending from the subcosta to the costa near the humeral angle of the wing (Fig. 6, *h*). This is the most constant of all of the cross-veins.

The radio-medial cross-vein. This is a cross-vein extending from radius to media, usually near the center of the wing, and is designated by the abbreviation *r–m*. When in its typical position, this cross-vein extends from R_{4+5} to M_{1+2}; this results in one end being opposite cell R_3 and the other end opposite cell 1st M_2. The cells are defined a little later.

The medio-cubital cross-vein. This is a cross-vein extending from media to cubitus, usually near the center of the wing. It is designated by the abbreviation *m–cu*. When in its typical position this cross-vein extends from a point near the base of M_{3+4} to a point near the base of Cu_1.

The medial cross-vein. This is a cross-vein extending from media-two (M_2) to media-three (M_3); this is designated by the abbreviation *m*. The presence or absence of this cross-vein is often a character of considerable taxonomic importance.

The arculus. In many insects there is what appears to be a cross-vein extending from radius to cubitus near the base of the wing. This has been termed the arculus by writers on the Odonata, and we propose to extend the use of the term to all orders in which there is a similar arrangement of the veins in this part of the wing.

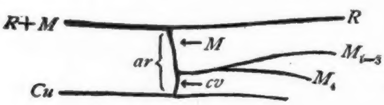


Fig. 7. — The arculus, diagrammatic.

The arculus is designated by the abbreviation *ar*. Usually when the arculus is present the media appears to arise from it. The fact is, the arculus is compound, being composed of a section of the media and a cross-vein. The structure of this part can be clearly seen in the Odonata (Fig. 7).

In descriptions of wings it is often desirable to refer to one or more of the cells. It is necessary, therefore, to have a nomenclature of the cells of the wing, as well as of the wing-veins. Certain of the cells have received special names; but as no effort has been made by those proposing them to trace the homologies of the cells beyond the limits of a single order, the names proposed are not available for our present purposes. A single example will serve to illustrate this. We find the term

discal cell used in descriptions of Lepidoptera, Diptera, Trichoptera, and Corrodentia (Psocidæ), but in no two of these orders is it applied to the same cell.

Having named the wing-veins, the simplest possible method of designating the cells of the wing is to apply to each the abbreviation of the name of the vein that forms its cephalic (front) margin. It should be borne in mind, however, that by modifications of the typical arrangement of the wing-veins, a vein that normally forms the cephalic margin of a cell may apparently bear a very different relation to it; and this must be taken into account if we are to apply the same term to homologous cells throughout the insect series.

The cells of the wing fall naturally into two groups: first, those on the basal part of the wing; and second, those nearer the distal end of the wing. The former are bounded by the principal veins; the latter, by the branches of the forked veins; a corresponding distinction is made in designating the cells. Thus the cell lying behind the main stem of radius and on the basal part of the wing is designated as cell R; while the cell lying behind radius-one is designated as cell R_1.

It should be remembered that the coalescence of two veins results in the obliteration of the cell that was between them. Thus when veins R_2 and R_3 coalesce, as in Leptis (Fig. 6), the cell lying behind vein R_{2+3} is cell R_3 and not cell R_{2+3}, cell R_2 having been obliterated.

When one of these principal cells is divided into two or more parts by one or more cross-veins, the parts may be numbered, beginning with the proximal one. Thus in Leptis (Fig. 6), cell M_2 is divided by the medial cross-vein into two parts, which are designated as 1st M_2 and 2d M_2, respectively.

The application of this system of naming the cells of the wing is an easy matter in those orders where the wings have few veins; but in those orders where many secondary veins are developed it is more difficult of application. In the latter case we have to do with *areas* of the wing rather than with separate cells. Thus, for example, it will be shown later that in certain Neuroptera the area R_2 is divided by several longitudinal veins, which are connected by many cross-veins, the area R_2 (which

is strictly homologous with cell R_2) being composed of a large number of secondary cells.

The wings of comparatively few insects present a flat surface; in most cases we find that the membrane is thrown into a series of folds or corrugations. This corrugating of the wing in some cases adds greatly to its strength. This is well shown by the wings of dragon flies; and in most orders the costal margin of the wing is strengthened by a fold between costa and radius, the *subcostal fold.* In other cases, the corrugations are the result of a folding of the wing when not in use; this is well shown in the anal area when this part is broadly expanded.

It rarely happens that there is occasion to refer to individual members of either of these classes of folds, except, perhaps, to the one that has just been designated as the subcostal fold. But there are three other furrows which it is necessary to designate, as we shall have frequent occasion to refer to them. These we term the anal furrow, the median furrow, and the nodal furrow, respectively. They may be defined as follows:

The anal furrow. This is a longitudinal furrow which is usually between the cubitus and the first anal vein (Fig. 6, *F*). It has been referred to by many writers, but the variableness of its position has not been pointed out.

The median furrow. This is a longitudinal furrow which is usually between radius and media. It is well marked in many of the Hemiptera, where it separates the embolium from the remainder of the corium; and in the Hymenoptera its course is marked by a series of weak spots (bullæ) in certain veins.

The nodal furrow. This is a transverse suture beginning at a point in the costal margin of the wing, corresponding to the nodus of the Odonata and extending towards the inner margin of the wing. It crosses a varying number of veins in different orders of insects.

The furrows of the wing are in no sense homologous or even analogous to veins. More than this, as will be shown repeatedly, the relative positions of the furrows and of the wing-veins are not constant; for it frequently happens that the course of a vein has been so modified that it crosses the line of a furrow and the relative positions of the two are thus reversed. If this fact

had been understood by Adolph we would have been spared his misleading theory of alternating concave and convex veins.[1]

II. The Venation of the Wings of Certain Plecoptera.

If we leave out of consideration the anal area, that portion of the wing traversed by the anal veins, we will find that in nearly every case each order of insects is characterized by either a reduction or a multiplication of the wing-veins; in certain orders the tendency is in one direction, while in others it is in the opposite. But either of these tendencies may be correlated with a similar tendency in the anal area or with the opposite one. In this chapter we purpose to point out the ways in which the primitive type of wing venation has been modified in representatives of several of the orders where a reduction in the number of wing-veins in the preanal area has taken place.

In the order Plecoptera, or stone flies, we find that, although in most genera the anal area of the hind wings has been expanded and the number of anal veins increased, in the preanal areas of both wings the number of wing-veins has been increased in certain genera and reduced in others; and we cannot say that either of these tendencies has yet attained the ascendency within this order.

This fact, taken in connection with the generalized condition of the basal attachments of the tracheæ of the wings, already pointed out, leads us to believe that the Plecoptera as a whole depart less widely from the primitive winged insect than do the living representatives of any other order.

In this place, we have to do only with those Plecoptera in which a reduction in the number of wing-veins in the preanal area of the wing has taken place. Of these, the genera Nemoura and Tæniopteryx are taken as examples. And we use, for the purposes of this study, wings of nymphs taken at a stage when the forming wing-veins appear as light-colored bands and the tracheæ, about which they are formed, as dark lines.

[1] G. Ernst Adolph, Ueber Insectenflügel. *Nova Acta der ksl. Leop.-Carol.-Deutschen Akademie der Naturforscher.*, Bd. xli, pp. 215–251. 1879.

In the nymph of Nemoura (Fig. 8) we have not observed a costal trachea. The subcosta is forked in the typical manner, and vein Sc_2 anastomoses with vein R_1. The radius is reduced, the radial sector being only two-branched; it is probable that this reduction came about by the coalescence outward of vein R_2 with R_3 and of vein R_4 with R_5. The media is reduced in a similar way. The cubitus is typical, but in the fore wing sev-

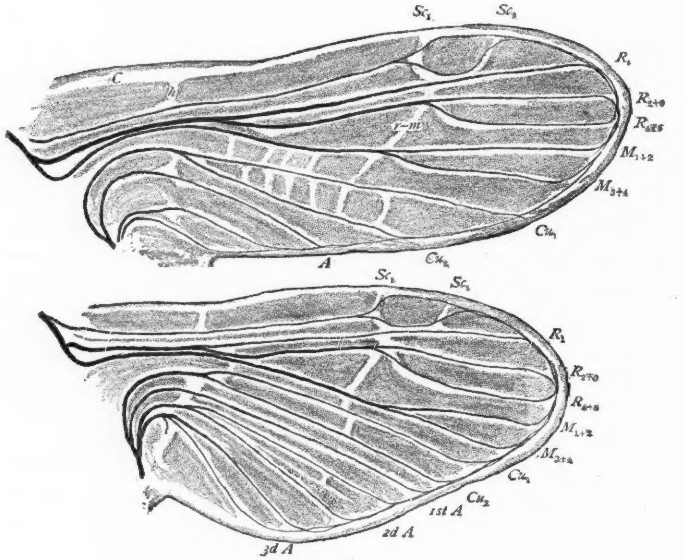


Fig. 8. — Wings of Nemoura, nymph.

eral cross-veins have been developed between its branches, and also between it and the media; the strengthening of this region of the fore wing is quite characteristic of the Plecoptera. The anal veins are typical in the fore wing, but in the hind wing the second and third anal veins are each forked.[1]

[1] There is a striking similarity between the anal areas of the Plecoptera and the Orthoptera; throughout both these orders the first anal vein remains simple in both wings, but the second and third anal veins are forked when this part of the wing is expanded.

The wings of a nymph of Tæniopteryx (Fig. 9) show a slightly different modification of the type. The costal trachea is well preserved. The subcosta is typical. The radial sector is reduced

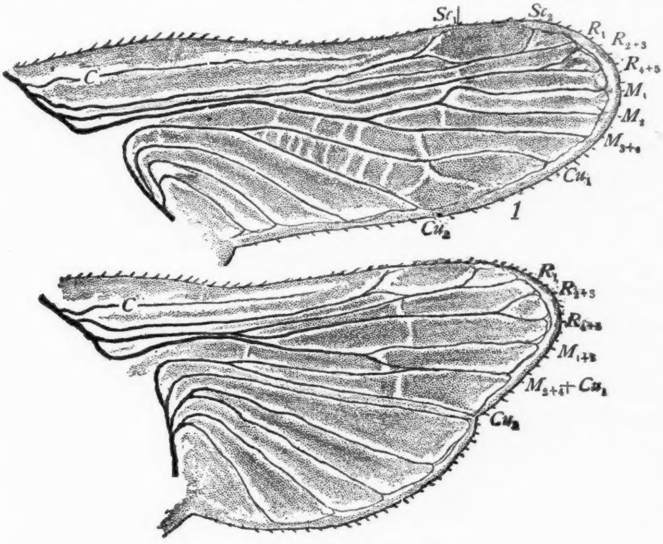


FIG. 9. — Wings of Tæniopteryx, nymph.

even more than in Nemoura, the coalescence of veins R_{2+3} and R_{4+5} having extended to near the margin of the wing; the carrying of this process a little farther would reduce the radial

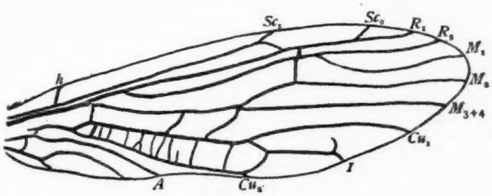


FIG. 10. — Wing of Tæniopteryx, adult.

sector to an unbranched condition, which is what has happened in some species of this genus (Fig. 10). The media is three-branched in the fore wing and two-branched in the hind wing, but in the hind wing vein M_{3+4} coalesces with vein Cu_1. The

cubital trachea is typical in both wings, and the anal veins are quite similar to those of Nemoura.

There are two points of especial interest in the fore wing of this insect, both showing the importance of ontogenetic study in determining the homologies of wing-veins.

First, it is evident that, correlated with the great reduction of the radial sector, vein M_1 of the fore wing, which remains distinct from vein M_2 in this genus, has come to perform the function that is performed by vein R_{4+5} in Nemoura; and, as a result, it has assumed a similar position. So great is the similarity that one who studied only the wings of the adult Tæniopteryx would be certain to mistake vein M_1 for a branch of the radial sector. A glance at Fig. 10, which represents the fore wing of the adult of another species of this genus, will make this more evident. If the object in view were merely to number the wing-veins, it may be that a mistake of this kind would not be serious; but when the object is to determine the relationships of allied forms, such a mistake would surely lead one astray.

The second point illustrates specialization by addition, and it is anticipating somewhat to allude to it here. It will be observed that in Fig. 10 a vein which ends in the margin of the wing midway between veins Cu_1 and Cu_2 is labeled 1. This is what we shall define later as the first accessory cubital vein A reference to Fig. 9 will show that, although this vein has the same appearance as other longitudinal veins in the adult, it is not preceded by a trachea in the nymph, but, like the cross-veins, is formed secondarily. This is an illustration of the beginning of a process which is carried to a great extent in those insects that have wings with many wing-veins, and which will be described in more detail later.

It will be seen from these two illustrations that a study of the ontogeny of the wings opens a fruitful field to one engaged in a study of the genetic relationships of winged insects.

III. The Venation of the Wings of Psocus.

The determining of the homologies of the wing-veins in Psocus and allied genera is a problem that has sorely puzzled all who have worked upon it; and it has remained till now

unsolved, although it has been attacked by such writers as Hagen, McLachlan, and Kolbe.

But when it is approached by the ontogenetic method the difficulties vanish, and it is hardly necessary to do more for its solution than to refer to the accompanying figures representing

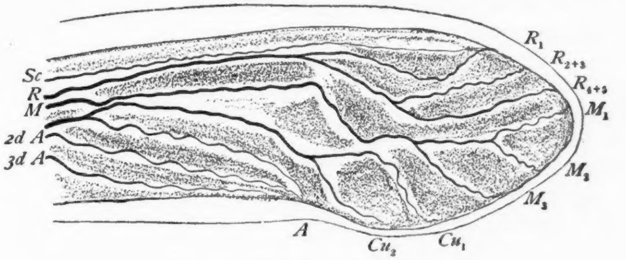


Fig. 11. — Psocus, fore wing of a nymph.

three stages in the development of the fore wing of *Psocus venosus*. When one understands this wing, the working out of the homologies in the hind wing, which is more reduced, and in the wings of other genera is a comparatively simple matter.

Fig. 11 represents the wing of a nymph which was not yet full grown. The lettering of the figure indicates the homologies

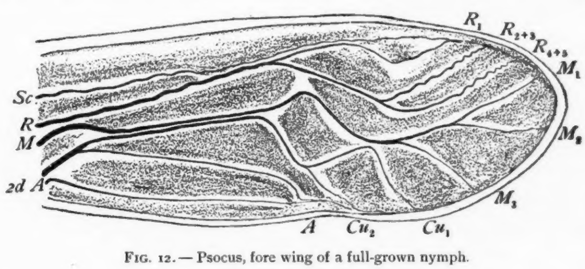


Fig. 12. — Psocus, fore wing of a full-grown nymph.

of the tracheæ. The formation of the wing-veins has begun, but in most cases the outlines of these are vague. It will be observed that the wing is much smaller than the enveloping sheath.

Fig. 12 represents the wing of a full-grown nymph. Here the forming veins are much more definite in outline, and there is no difficulty in tracing the venation of the adult wing. The

costal trachea is preserved for only a short distance; the subcostal trachea extends far beyond the end of the forming vein; and for a considerable part of its course is within the light band that is to form the radius; the radial sector has been reduced to two branches; and only three branches of the media remain. The most striking features of this wing are the coalescence of media and cubitus, which is shown by the two tracheæ being

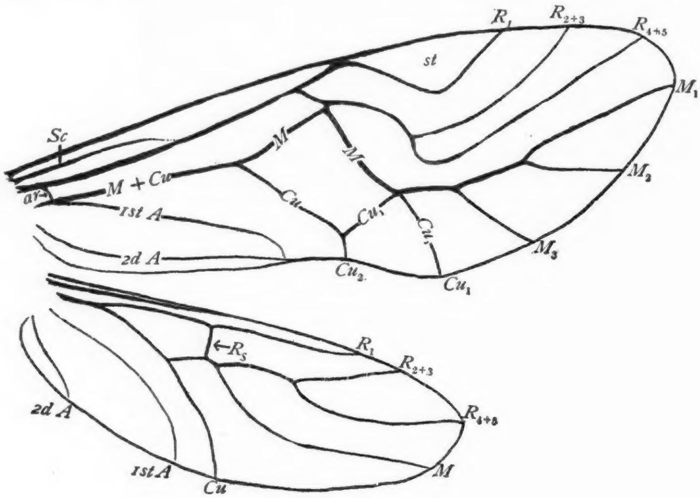


FIG. 13. — Psocus, wings of an adult.

closely parallel for a considerable distance within a single vein, and the zigzag course of media, which is easily determined by following the course of the medial trachea. Neither of these features is so well marked in the less mature wing. The first anal vein coalesces with cubitus at the base. The second anal vein has moved nearer to the margin of the wing. And the third anal trachea is no longer visible.

The wings of the adult are represented by Fig. 13. A remarkable feature of these wings is that, although they are braced in every direction, there is not a single cross-vein present, except an arculus which is formed of the base of the media; the bracing is accomplished by the zigzag courses of the prin-

cipal veins. This, however, is not true of all psocids. In some the bend in the media does not reach the radial sector, and the two are connected by a radio-medial cross-vein.

The margin of the adult wing is tubular throughout, there being what has been termed by writers on the Diptera an ambient vein. The costal and anal portions of this doubtless represent the costa and third anal veins, respectively, although the corresponding tracheæ are apparently lost. The distal portion of this ambient vein was preceded by the anastomosing tips of all of the veins, as is shown in the figures of the nymph wings. In the fore wing the tip of the subcosta coalesces with the radius; in the hind wing it coalesces with the costa. In the fore wing a large stigma is developed in an angle of vein R_1; and in both wings the anal furrow coincides with the first anal vein.

IV. The Venation of the Wings of a Cicada.

A study of the wings of Hemiptera reveals remarkable departures from the primitive type of wing venation. So great are these that, at first, one sees very little in common between the wings of a bug and those of insects of any other order. We were filled with delight, therefore, when we found within this order, preserved almost unchanged, what we had come to regard, from a study of other orders, as the primitive type of wing venation.

The conservative Hemiptera that retain most perfectly the fashions of ancient times, so far at least as concerns the venation of the wings, are the cicadas. But the slightness of the changes that have taken place is not obvious if one studies only the wings of the adult; for in this stage there is a massing of several veins along the costal margin of the wing, and the cross-veins have the same appearance as the branches of the primary veins.

In the wings of a young nymph, on the other hand, the tracheæ that precede the primary veins are not massed as they are later, and in the older nymph where the forming veins appear as pale bands the cross-veins contain no tracheæ.

In the wing of a nearly mature nymph (Fig. 14) the costal trachea extends nearly to the apex of the wing. The subcostal trachea is also prominent, but it is not forked. The radius is reduced to a three-branched condition. The media is typical. So, too, is the cubitus. The first anal trachea coalesces with the cubital trachea for a considerable distance. The second and third anal tracheæ are also united at the base, and the forming veins appear as pale bands.

The important departures from the primitive type are two: first, the coalescence of the first anal vein with the cubitus. This results in the anal furrow of the adult lying between the first and second anal veins; but these two are closely opposed

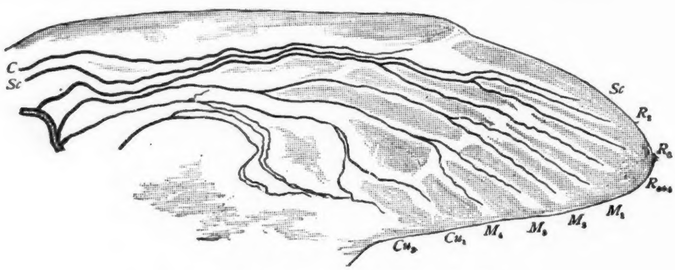


FIG. 14.— Cicada, fore wing, mature nymph.

in the fore wing of the adult, except for a short distance at the base of the wing, so that they appear as a single vein along the line of the furrow. The study of the wings of an adult which was killed at the moment of emergence from the nymph skin, and in which the tracheæ of the wings are distinctly visible within their corresponding wing-veins, has materially aided us in determining the relation of the anal furrow to the adjacent veins. It may be said in this connection that the coalescence of the first anal vein with the cubitus is a common occurrence in several of the orders.

A more striking departure from the primitive type is the reduction of the radius. For a long time we were unable to decide in what manner this had taken place. The usual mode of reduction of this vein is by the coalescence outward of the two branches of each half of the radial sector, leaving the

sector two-branched and the vein as a whole three-branched, as in Nemoura and in Psocus. But in these cases the intermediate branch of the radius arises from the posterior one of the three; in Cicada, on the other hand, the intermediate branch arises from the anterior one of the three (Fig. 14).

It was not till we succeeded in obtaining a very young nymph of Cicada that this question was definitely settled. In the fore wing of this nymph (Fig. 15) the radial trachea is five-branched; and the only departure from the typical mode of branching is

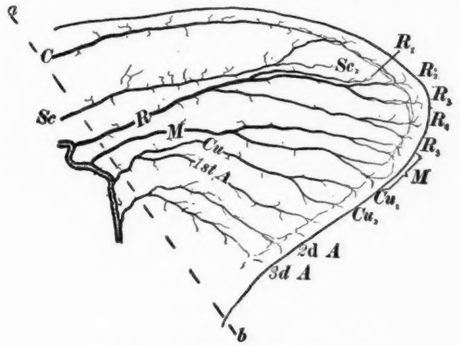


FIG. 15. — Cicada, fore wing, young nymph.

that the branch which corresponds to vein R_1 coalesces for a short distance with the one corresponding to the anterior half of the radial sector.

It will be observed that in this part of the wing the subcostal trachea closely approaches the radial. This crowding of the radial trachea by the subcostal is doubtless the explanation of the pushing outward of the point of separation of the trachea R_1 and of the complete atrophy of this trachea in the later stages of this insect, which results in the non-development of vein R_1.

We have discussed this matter at some length, not merely to show the close correspondence of the tracheation of the wing of the young nymph to our hypothetical type, but also to point out the course by which has been reached one of the most characteristic features of the venation of the wings of Hemiptera, that is, the complete absence of vein R_1.

From a study of the two nymph wings figured here, it is an easy matter to trace the homologies of the veins and cells of

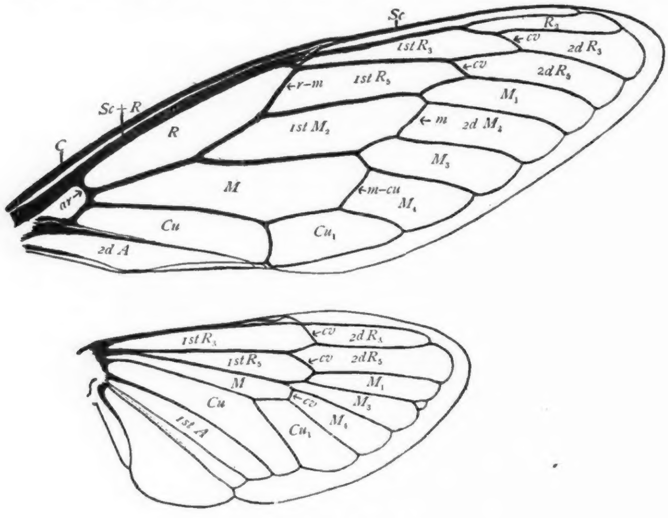


FIG. 16. — Cicada, wings of adult.

the fore wing of the adult; these are indicated by the lettering of this part in Fig. 16.[1] The more difficult points are eluci-

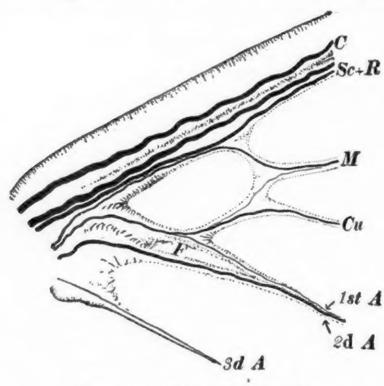


FIG. 17. — Cicada, base of fore wing.

[1] In those cases where the veins are not numbered, their homologies are indicated by the numbering of the cells behind them.

dated by Fig. 17, which represents the base of the fore wing of the adult, and Fig. 18, which represents the region of the nodal furrow of the same wing. These figures are based on a study of the recently emerged adult, already referred to. We

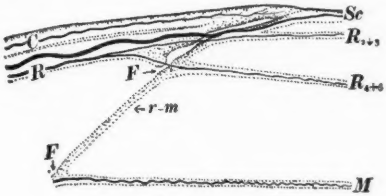


FIG. 18. — Cicada, nodal furrow of the fore wing.

wish to call attention especially to the coalescence of subcosta and radius from the base of the wing to a point near the nodal furrow, as this is a feature which occurs in a large proportion of the families of the Hemiptera.

The changes that have taken place in the hind wing of Cicada are much greater than those of the fore wing, and it would be

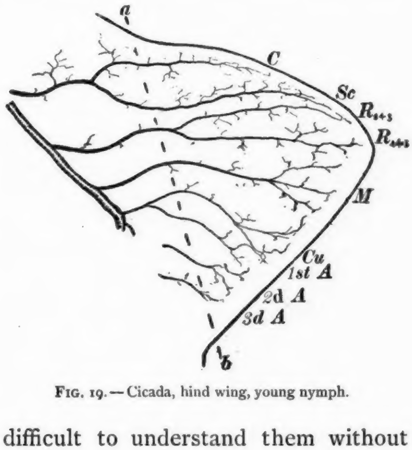


FIG. 19. — Cicada, hind wing, young nymph.

exceedingly difficult to understand them without the aid of ontogenetic study. But a careful comparison of the hind wing of a young nymph (Fig. 19) and the base of the hind wing of the recently emerged adult (Fig. 20) has cleared up the doubtful points.

In comparing the wings of nymphs, and especially of young nymphs, with those of the adult, it will be found that the growth of the basal part of the wing proceeds more rapidly at first than does that of the distal portion. This is shown by the fact that the branching of the branched tracheæ occurs much nearer the outer margin of the wing in the nymph than does the branching of the corresponding veins in the adult.

The difference is not so great, however, as appears at first sight, for only a part of what is represented in Fig. 19 corresponds to the wing of the adult. The dotted line *a–b* indicates

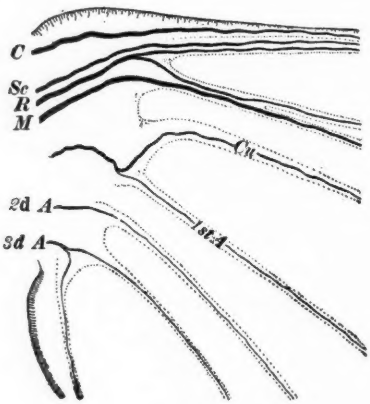


FIG. 20. — Cicada, base of hind wing.

approximately the line along which the hinge of the wing of the adult is formed. In Fig. 15, the line *a–b* represents the corresponding part in the fore wing.

By comparing Figs. 15 and 19 it will be observed that the forking of the radial trachea takes place much nearer the hinge line in the hind wing than it does in the fore wing. Upon this fact depends the most striking difference in the venation of the fore and hind wings of the adult.

In the fore wing we found that subcosta and radius coalesce to a point near the nodal furrow. But in the hind wing it is only the anterior half of what is left of the radius after the loss of vein R_1 that coalesces with the subcosta. The posterior half,

vein R_{4+5}, separates from vein R_{2+3} very near the base of the wing, and coalesces with the media for a short distance, after which it traverses the wing as a separate vein. A result of this is that while the 1st cell R_3 of the fore wing lies beyond the nodal furrow, in the hind wing it reaches the base of the wing; and the 1st cell R_5 occupies a similar position. A study of the base of the hind wing of the recently emerged adult (Fig. 20) confirms these conclusions.

Other features of interest in the hind wing are the following: The media is only three-branched as a rule, but in some specimens there is a small remnant of cell M_2. The first and second anal veins are widely separate, and the third anal vein is forked.

In the course of the development of the wing of Cicada there is an excellent illustration of the migration of the base of the medial trachea, which was referred to at the close of Chapter II. In the young nymph of Cicada (Fig. 15) the medial trachea arises from the transverse basal trachea midway between the radial and cubital tracheæ. In the mature nymph (Fig. 14) the base of the medial trachea has reached the cubital trachea.

In tracing the homologies of the tracheæ of the wings, it is very important that this migration of the base of the medial trachea be kept in mind. For while in the more generalized forms where there is no basal transverse trachea (Plecoptera and certain Blattidæ) the medial trachea belongs to the costo-radial group of tracheæ, whenever a basal transverse trachea is present the medial trachea either arises from it or is a member of the cubito-anal group. The ontogeny of Cicada gives conclusive evidence of this migration. In all mature nymphs of Hemiptera that we have examined the migration has taken place, the medial trachea being a member of the cubito-anal group.

V. The Venation of the Wings of Heteroptera.

In Cicada we found the most generalized condition of the wings that exists in the hemipterous insects that we have studied, and it is hardly to be expected that a more generalized

form will be found among the living representatives of this order. We have now to consider modifications of this type in representatives of the suborder Heteroptera.

In our studies of Heteroptera we have examined nymphs of the following families: Notonectidæ, Nepidæ, Belostomidæ, Reduviidæ, Nabidæ, Capsidæ, and Pentatomidæ. Of these there is no doubt that the most generalized condition of wing venation is found in the family last named, but further studies in other families may reveal a still more primitive type.

Fig. 21 represents the tracheation of the fore wing of a

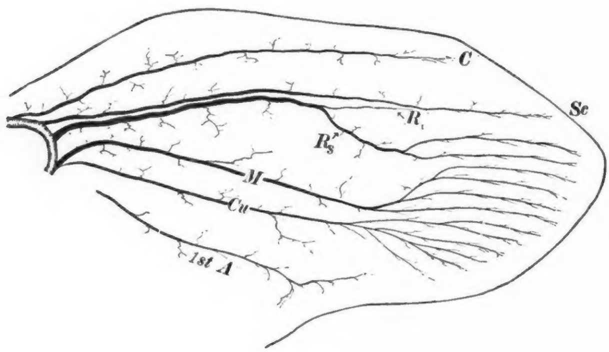


FIG. 21.—A Pentatomid, fore wing, nymph.

Pentatomid nymph. In this wing the costal trachea is well preserved. The subcostal and radial tracheæ are closely approximate in the basal half of the wing; in the distal half of the wing the subcostal trachea traverses that part of the wing which would be traversed by trachea R_1 were it well developed and in its typical position; but it is reduced to a rudimentary condition. It is evident that a supplanting of R_1 by the subcosta takes place here, as in Cicada. The trachea that precedes the radial sector has its characteristic bend at the base, and is two-branched. The medial trachea is typical, that is, four-branched. The cubital trachea is six-branched; it is evident that a specialization by addition has taken place here. Only a single anal trachea has been preserved.

The hind wing of the same nymph (Fig. 22) presents a very similar arrangement of tracheæ, except in a greater reduction of the radius.

Unfortunately, we did not rear any adults from nymphs of this species; hence we cannot give a figure of the adult wing of this particular insect. But an examination of many Pentatomids shows that in the thickened portion of the fore wing the tracheæ follow essentially the same course as in the nymph figured here. There are also faint longitudinal veins in the membranous terminal portion of the wing which doubtless

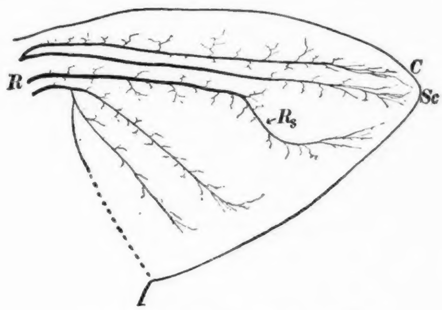


FIG. 22.—A Pentatomid, hind wing, nymph.

correspond with the tips and branches of the principal tracheæ. But at the base of the "membrane," as this terminal portion is designated by writers on the Hemiptera, a hinge line is formed, across which it is rarely possible to trace the tracheæ in dried specimens. The veins of the membrane appear to be connected by cross-veins parallel with this hinge line and close to it, and have but slight connection with the veins of the basal part of the wing except near the end of the anal furrow. We are not able, therefore, with the material at hand, to work out the homologies of the veins of the membrane, and must be content with pointing out at this time the more important features of the thickened portion of the wing.

In those Pentatomids in which we have been able to trace the courses of the tracheæ of the wings, the wing-veins are comparatively inconspicuous. We figure on this account one

of the Coriidæ (*Hormostes reflexulus*) of which we have a specimen in which the tracheæ are distinctly visible within the well-developed veins (Fig. 23).

At the base of the wing the costa is remote from the costal edge of the wing, but approaches it near the middle of the

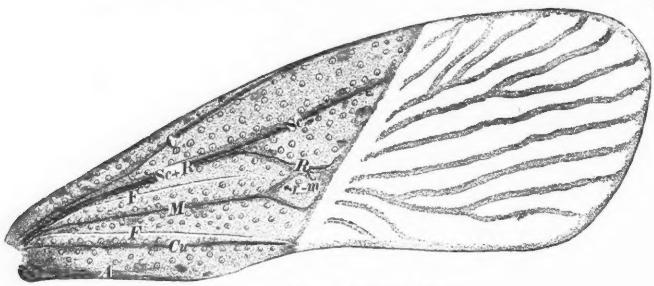


Fig. 23. — A Coreid, fore wing, adult.

thickened portion. The subcosta and radius coalesce to a point beyond the middle of this part of the wing, where the radial sector separates, making its characteristic curve. Vein R_1 is wanting. Media, cubitus, and the first anal vein extend in nearly direct lines to the membrane.

The most important feature of the venation is the coalescence of subcosta and radius, a feature that occurs in many families of Hemiptera.

But the most important features to be observed are the positions of the furrows of the wing. Here the median furrow is in its typical position between radius and media. In the Pentatomids that we have studied it is more closely parallel with the radius and extends across the radial sector, showing that its position is not determined by the course of the veins. The anal furrow is in front of the cubitus instead of in its more usual position, behind this vein. In fact, in all of the Heteroptera that we have examined, when an anal furrow is distinctly developed it is in front of the cubitus.

Much remains to be done in tracing out the homologies of the wing-veins of the Hemiptera. But we feel that a good beginning has been made, one which will serve as a sure basis for future studies.

VI. The Venation of the Wings of Lepidoptera.

In the order Lepidoptera the primitive type of wing venation is well preserved in certain of the Jugatæ. This is shown in Sthenopis (Fig. 24). In the species figured here, the deviations from our hypothetical type are few. In the fore wing, veins M_4 and Cu_1 coalesce for the greater part of their length, and one of the anal veins has been lost. In the hind wing, veins M_4 and Cu_1 anastomose, but separate near the margin of the wing.[1]

In the Frenatæ we find the primitive type well preserved in the fore wings of the more generalized forms. The most striking departure from our hypothetical type is the fact that the

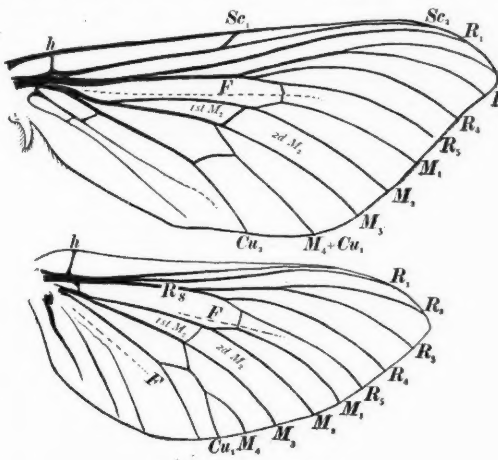


Fig. 24. — Wings of Sthenopis.

media is never more than three-branched;[2] and this is true also of the media of the hind wings. The wings of Prionoxystus

[1] This is not true of the genus as a whole; usually these veins coalesce in the hind wings as in the fore wings.

[2] With our present knowledge it is impossible to determine the way that vein M_4 has disappeared in the Frenatæ. We have seen no indication that it coalesces with vein Cu_1 as in Sthenopis, for in all pupæ of this suborder that we have examined the medial trachea is only three-branched. We are obliged, therefore, to omit any further reference to this vein in the discussion of this order.

(Fig. 25) will serve to illustrate the type of venation characteristic of this suborder.

In the fore wing the branches of radius appear to present a complicated arrangement, but this is merely due to the anastomosis of veins R_3 and R_4; except for this the radial sector has preserved its primitive type. In this wing the bases of veins M_2 and M_3 have migrated towards the cubitus, so that cells 1st M_2 and 2d M_2 are not opposite each other (cell 1st M_2 is the small triangular cell near the center of the wing).

In the hind wing a great reduction of the subcosto-radial

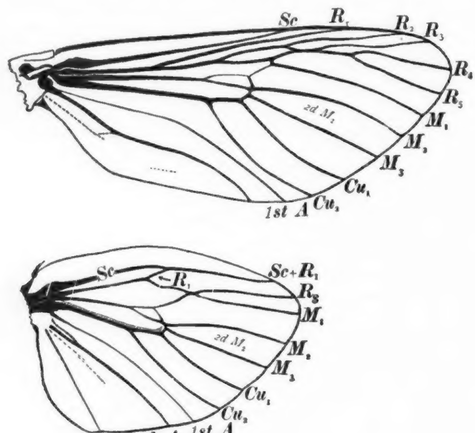


FIG. 25. — Wings of a Prionoxystus.

area of the wing has taken place. This has been brought about in two ways: first, veins Sc and R_1 coalesce from the margin of the wing nearly to the base of R_1;[1] and second, the radial sector is reduced to a single vein, R_s.

We have space to point out only one, the most important, of the ways in which this type is modified in the Frenatæ. It will be observed that the basal half of the wing, being traversed by the main stems of all of the veins, is stiffened to a great extent. Evidently, from what has taken place in the more specialized

[1] In pupæ of Frenatæ the subcostal trachea and the first branch of the radial trachea are distinct. This fact was first pointed out by Spuler.

families, there is more vein-material here than is necessary or perhaps desirable, for we find a very general tendency towards the atrophy of the base of the media.

An excellent record of what has taken place is preserved in the fore wing of the adult of Anosia (Fig. 26). Here the base of the media has disappeared, but there remain three little spurs projecting back into cell $R+M$ (indicated by the arrows) which show the positions occupied by the three branches of the media when the base of this vein ceased to be of use. It should be

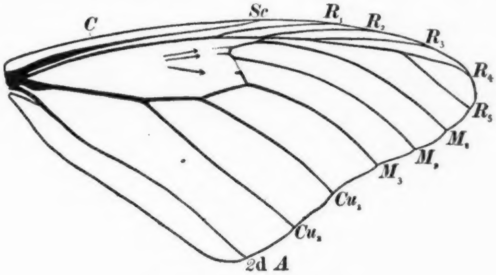


FIG. 26. — Fore wing of Anosia.

observed that in the pupa of this butterfly the medial trachea is well preserved throughout its entire length; the atrophy of the base of the media pertains only to the adult state.[1]

Correlated with the atrophy of the base of the media, there arises a necessity for a new source of air supply for the medial area of the distal half of the wing of the adult, and probably also for a better bracing of this part of the wing than would exist if no other changes were made. These are furnished by a more intimate connection of the branches of the media with the adjacent veins, vein M_1 becoming more intimately connected with the radial sector, vein M_3 with cubitus-one, and vein M_2 with one or the other of these veins, differing in different families.

There result from the changes just pointed out striking modifications of the courses of the veins concerned. Note, for example, that the base of vein M_3 in Anosia (Fig. 26) has

[1] Figures of the wings of pupæ of Lepidoptera are omitted, as several have been published by Spuler and others.

migrated away from the spur indicating its more primitive position, and that the medio-cubital cross-vein (*m-cu*) is no longer transverse, but appears to be a continuation of the main stem of the cubitus.

VII. THE VENATION OF THE WINGS OF TRICHOPTERA.

In the preceding pages much evidence has been given to show the importance of studying the tracheæ that precede the wing-veins, in order to determine with certainty the homologies of the latter. But in some of the orders of insects a remark-

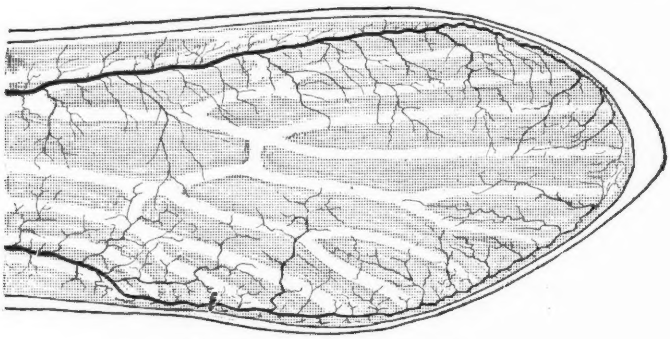


FIG. 27. — Wing of a pupa of a caddice fly.

able reduction of the wing tracheæ has taken place, which renders them useless for this purpose. This is true of the Trichoptera and Diptera, and also to a considerable extent of the Hymenoptera.

If the wing of a pupa of a caddice fly be examined at that stage when the forming wing-veins appear as pale bands, it will be seen that the tracheation of the wing bears but little relation to the wing-veins. Usually only two or three main tracheæ are present; and although these may coincide with forming veins, their branches bear no relation whatever to veins (Fig. 27).

Fortunately, in the case of the Trichoptera we do not need to study tracheæ in order to determine the homologies of the wing-veins; for here, in the more generalized members of the order, we find the primitive type of wing venation well preserved.

The fore wing of Hydropsyche (Fig. 28) with a slight modification would serve as a typical insect wing. Excepting the coalescence of anal veins at the tip, the number and arrangement of the longitudinal veins in this wing correspond exactly with our hypothetical type; and only those cross-veins are present that may be considered typical on account of the fre-

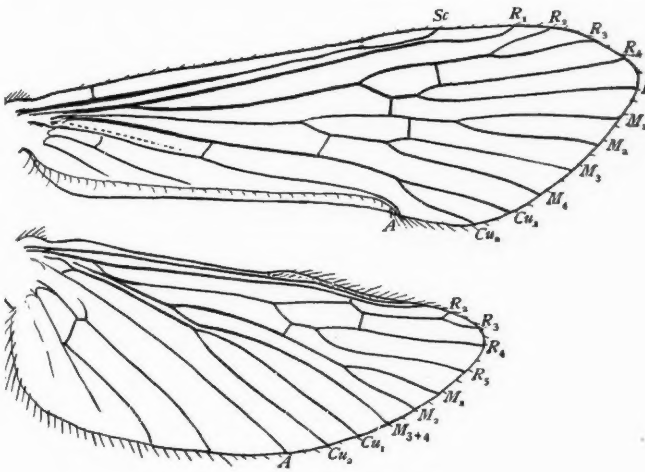


Fig. 28. — Wings of Hydropsyche.

quency with which they occur in the more generalized members of different orders.

In the hind wing the media is only three-branched and a tendency towards an increase in the number of anal veins is evident. This expansion of the anal area of the hind wings has been carried to a considerable extent in certain members of the order.

Lack of space prevents a discussion of the various ways in which the primitive type of wing venation is modified within this order. But such a discussion is hardly necessary, for it is not difficult to understand the venation of the wings of these insects.

Entomological Laboratory,
Cornell University, January, 1898.

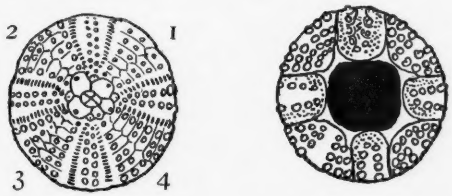
BRIEFER ARTICLES.

A CASE OF VARIATION IN THE NUMBER OF AMBULACRAL SYSTEMS OF ARBACIA PUNCTULATA.

HENRY L. OSBORN.

THE growing interest in variation, stimulated by the appearance of Bateson's[1] work on that subject, seems to make it worth while to record cases of variation even where they are isolated, and it is for this reason that I make the following record. The specimen is the only one thus far met with in the course of several years in using Arbacia and Strongylocentrotus, so that it can be regarded as rare. The number of Arbacias that have passed through my hands cannot be less than two hundred, and of Strongylocentrotus, not less than twice that number, and I have not before met a case in which the number of ambulacral systems was less or more than five. I was, therefore, somewhat surprised when a student presented me with a drawing of an Arbacia in which the number was four, and at first was inclined to doubt the accuracy of the work; but the specimen itself was placed in my hands and showed that this departure from the typical number does occur in this species.

The specimen came to me dried. It came from Woods Holl in a lot of supplies furnished by Mr. W. H. Walmsley, and the position



Aboral and oral aspects of a four-rayed individual of Arbacia punctulata from the coast of Massachusetts.

of the soft parts can only be inferred from the test, which, however, is fairly indicative of the internal anatomy in this class of animals. Two views of the test are shown in the accompanying cut. That of

[1] *Materials for the Study of Variation.* Macmillan, 1894.

the oral surface is perfectly four-rayed instead of five. Four perfect ambulacral rows alternate with four perfect inter-ambulacral rows. On the aboral side, too, the ambulacral rows are completely four-rayed instead of five-rayed. The lantern, too, is completely four and not five-parted; its relation to the peristome membrane is apparently the same as in the normal cases. But a break in the four-rayed plan occurs in the aboral ring of bones. In this ring there are three large genital bones which terminate rows numbered 1, 2, and 3 of the figure, No. 1 being the madreporic plate; but the fourth row is terminated by two smaller genital bones, each perforated for the opening of the genital duct. One of these bones is at the summit of one of the two rows of bones in the inter-ambulacral area, and the other is at the summit of its mate. There are, however, only four instead of the normal five ocular plates. The position of the anal plates is normal, *i.e.*, there are four, and the plane between two passes through the madreporic plate at the summit of area No. 1. The test as a whole is entirely symmetrical, and the variation is not betrayed by any even slight loss of symmetry; the outline is quadrilateral, not pentagonal as usual.

It seems from the study of the test that what has happened has been the failure of one entire ambulacral system to appear, that is, two ambulacral rows of bones and the neighboring inter-ambulacrals on each side have not developed at all, while as a consequence the inter-ambulacrals of two rows, *viz.*, that on the left side of row No. 4 and that on the right side of row No. 5, have been matched together, so that row marked actually No. 4 is really a part of row No. 4 and a part of row No. 5, the balance of each having been suppressed so early that there is no trace of them left. The apical organs, however, were not included in this suppression, and hence the genital plates, and presumably the reproductive organs as well, are in fives.

This case does not exactly correspond with any of the cases cited by Bateson (pp. 443 *et seq.*), for his list does not provide for a case in which there is a total variation to a four-rayed form in the ambulacrals and inter-ambulacrals, and perfect symmetry among these parts, and at the same time only partial approach to the four-rayed form in the apical system. His case No. 676 (p. 441) is totally four-parted, and there are four genitals and four oculars, and case No. 677 also has the apical system, as well as the ambulacrals four-parted. The only cases of partial meristic variation which he gives are those in which some of the ambulacral systems are partly subdivided by the intercalation of some of the missing bones. The presence of the

five genitals makes it possible to conclude that in this case the missing ambulacral row (using the nomenclature of Lang, *Comp. Anat.*, vol. ii, p. 321, Macmillan, 1896) is the right posterior one.

Biological Laboratory of Hamline University,
St. Paul, Minn., February 1, 1898.

RELATIONSHIP OF THE CHRIACIDÆ TO THE PRIMATES.

CHARLES EARLE.

It would be interesting if some especially clear-headed paleontologist would define the order Creodonta and explain how it is to be separated from the Insectivora. If we include forms like Chriacus in the Creodonta, we shall be obliged to follow Wortman's suggestion and unite the creodonts and insectivores in one common group.

It must be granted that the creodonts of the Puerco were well differentiated and somewhat specialized; this is proven by the presence of such forms as Deltatherium and Didymictis, the latter genus having developed already the true sectorials of the higher carnivores. It remains to be shown whether the peculiar upper molars of the Mesonychidæ are primitive or degenerate. If Dissacus is really the ancestor of Mesonyx, then this series illustrates an important point in tooth morphology, and would help to settle the vexed question whether the order of appearance of the cusps of the true molars is really different from that of the premolars. In Dissacus and Pachyæna, for example, one would be led to conclude that the antero-external cusp of the upper molars was the first one to appear and its position had not been changed. In the case of these teeth it is hard to believe that there had been any rotation inwards of the protocone such as the advocates of the triconodont-tritubercular theory would make us believe.

The genus Chriacus and its allies have little in common with the above-mentioned creodonts, and I fail to see why they should be classified with them. It appears to me to be out of the question to imagine that the primates have any close relationship to the Condylarthra such as Cope supposed. That the condylarths were all ungulate types has been admitted, and, in fact, it is one of their important diagnostic characters that they were hoofed quadrupeds.

It has been most interestingly shown by Dr. W. D. Matthew how closely one of the earliest condylarths, Euprotogonia, approaches in

the structure of its skeleton that of the creodonts, and it appears most probable that these primitive hoofed forms came from clawed types. Now Hubrecht, on embryological grounds, derives the most primitive of living lemurs, Tarsius, from an insectivorous-like ancestor. I have endeavored to prove that all lemurs must have originated from unguiculate types, and that the anatomical characters which the extinct and living lemurs have in common with the ungulates probably arose independently of the latter.

It is very curious, if the mammals of the Puerco were such primitive forms, that this fauna contains so few types which led up to later genera. Among the generalized types of the Puerco I think we can designate Chriacus as such, and I believe that it may be related ancestrally to that curious group of pseudo-lemurs, the Hyopsodontidæ. Now Hyopsodus has a skull resembling very closely that of Adapis, although the structure of the teeth in these genera is absolutely different. What is known of the skeleton of Adapis shows that the proportions of the limbs are similar to what is found in Nycticebus, the anterior limbs not being elongated as in Tomitherium.

I fail to see that any new evidence has been brought forward to prove that Chriacus is not a primate, or, better, an insectivore related ancestrally to the Bridger pseudo-lemurs, Pelycodus and its allies. Surely the structure of the teeth in Chriacus is more like an early primate or insectivore than that of any of its contemporary creodonts of the Puerco. The spacing of the premolars in Chriacus is no objection to its being related to the primates, for among living lemurs we meet with forms with slight intervals in their dentition. Again, the large canines of Chriacus are like those of Pelycodus or Adapis, and the long, slender jaw may be considered a primitive primate character.

In conclusion, it appears to me that the Chriacidæ would find a more "congenial location" either in the Insectivora or as very primitive primates which had just emerged from the former group. If the Chriacidæ can be conveniently placed among the Insectivora and are shown to be related to Pelycodus and related forms, then a decided advance has been made in connecting the later Eocene group of primitive American lemurs with those of the Puerco.

NEW ROCHELLE, N.Y.,
January 10, 1898.

FURTHER NOTES ON THERMOMETER CRICKETS.

CARL A. BESSEY AND EDWARD A. BESSEY.

THE article on "The Cricket as a Thermometer" by Professor Dolbear in the November *Naturalist* reminds us of a series of somewhat similar observations upon the chirping of the tree cricket (*Œcanthus niveus*) which we made in Lincoln, Nebr., during August and part of September of the past summer.

Noticing that the rate of chirping was approximately the same in different parts of the city for any particular time, but that this rate varied in a marked degree from day to day, we were led to make an investigation of the conditions accompanying these variations. We began taking observations upon this rate along with thermometer readings on August 13.

Finding that each cricket remained in the same tree for days at a time and that in different trees the rate was often slightly different, we thought best to take a series of observations on certain individual insects. These were designated for convenience as A, B, C, etc. For example, we found that at a temperature of 66.5° F., B chirped 122, E 121, F 122, and G 118 times per minute. Through a quite wide temperature range G almost invariably chirped at a lower rate than either E or F.

Observations were made on the rate of chirping of eight different crickets for periods ranging from a few days to about three weeks. Some could be distinguished for only a few days, while others, notably E and F, chirped very regularly every evening for three weeks or more. On evenings when the temperature was falling rapidly, observations were made several times, with results very markedly showing the effect of temperature change. For A five different observations were made, for B nine, C four, D one, E thirty, F twenty-two, G ten, and H five.

One cool evening a cricket was caught and brought into a warm room. In a few minutes it began to chirp nearly twice as rapidly as the out-of-door crickets. Its rate very nearly conformed to the observed rate maintained other evenings out of doors under the same temperature conditions.

From this series of observations we found that the rate of chirping was, as Professor Dolbear says, very closely dependent on the temperature.

Plotting the chirps per minute as ordinates, and temperatures (degrees Fahrenheit) as abscissæ, we obtained a series of points whose maximum deviation from a straight line was only about six per cent. From this we deduced the relation

$$T = 60 + \frac{N - 92}{4.7},$$

where T stands for temperature, and N for chirps per minute. For temperatures between 60 and 80 this equation is accurate within one

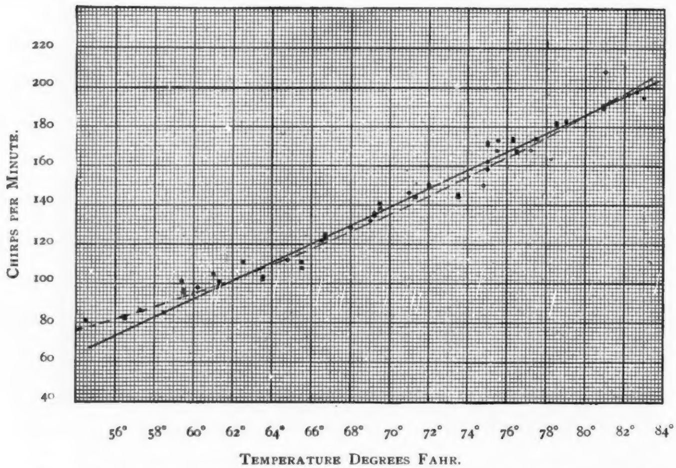


Figure showing the correspondence between temperature and rate of chirping. The solid straight line conforms to the formula; the dotted curved line is evidently somewhat closer to the observed facts.

or two degrees. Below 60, however, the insects chirp at a somewhat faster rate than would be expected from the formula, and consequently the calculated temperatures would be two or three degrees too high.

This deviation shows that the actual relationship between the rate of chirping and temperature cannot be exactly expressed by a straight line, as in our diagram, but should rather be expressed by a curve approximating that shown in the figure by the dotted line.

THE UNIVERSITY OF NEBRASKA.

POLLINATION OF THE CLOSED GENTIAN BY BUMBLEBEES.

R. J. WEBB.

On the morning of Sept. 3, 1897, while walking by a moist spot, I came across a fine cluster of the closed gentian (*Gentiana andrewsii*). My attention was also attracted by three or four bumblebees which were buzzing among the flowers, and, watching these, I saw that they were working upon the blossoms of this plant.

One of them poised itself above a flower and inserted its proboscis in the dimple formed by the overlapping plaits, and by dint of considerable exertion and wriggling and twisting about, it was able to force the corolla open and crawl in until it reached the nectar which is found at the base of the tube. It remained thus partly in the flower for four or five seconds, then backed out and flew to another blossom. This operation was repeated many times, for I watched the same bee enter fifteen or twenty flowers, and the others were also working away at the same time. They usually crawled in until about half inside, and while in this position would often kick and twist about. All the insects' strength was required to force open some of the flowers, and the ones which were immature and hence not ready for fertilization they were unable to enter at all.

On October 4 I examined the same patch and found nearly every capsule full of perfect seeds.

This would seem to show that the plant is entomophilous and is fertilized by bumblebees, as was believed by Dr. Gray, who once saw one of them force its way into the corolla. Dr. Kunze and others have regarded this plant as autogamous.

GARRETTSVILLE, OHIO.

EDITORIALS.

National Scientific Appointments. — The history of the Smithsonian Institution, considered in the previous issue, is a highly creditable one. That it is so is doubtless due to the high character of its secretaries. In their eminent fitness for the positions they have filled they constitute a striking contrast to the series of heads of other governmental scientific bureaus. The reason for this contrast is doubtless the different method of appointment. The chief of many scientific bureaus is appointed by the President, who is subjected to the importunities of politicians who have a debt to pay to some political friend. Such importunities it is more than human always to resist. The President should be relieved from them in the case of the scientific bureaus. The experience of the Smithsonian Institution suggests the method. The secretary is here appointed by the Board of Regents, composed of the Chief Justice of the Supreme Court of the United States, who is also the presiding officer, the Vice President of the United States, three Senators appointed by the Vice President, three members of the House of Representatives appointed by the Speaker, and two citizens of Washington and four "citizens of a state" appointed by joint resolution of Congress. Such a committee, meeting at least once a year, soon catches the spirit of the Institution, and seeks only its best interests; at the same time it keeps the bureau in touch with Congress, to which it looks for appropriations. Another point: the two secretaries who have succeeded Henry have held the office of first assistant secretary. Thus a continuity in the administration of the office has been secured. The moral of the experience of the Smithsonian Institution is that the appointment of the chiefs of our national scientific bureaus should be made by boards composed of scientific men and members of Congress, who shall keep in touch with the workings of the bureau, and shall, as far as possible, in their appointments follow the principle of promotion.

A Uniform System of Craniometry. — The deplorable lack of harmony which still exists in the measurements and methods of craniologists is discouraging to the student, and renders the results obtained by each observer of less value to others for compara-

tive purposes. The selection of a common series of cranial measurements does not present the practical difficulties that oppose the adoption of the coming international scientific language. The number of measurements having a practical ethnic or descriptive value is less than one hundred; nearly all of these have been in use for years, and their relative importance has been pretty accurately determined. The spirit of courtesy and fairness which characterizes the true scientist should induce each one to sacrifice some of his allegiance to tradition, in order that a system may be devised that shall require no explanation, and which shall be as accessible to the Russian as to the American. We may be ready to accept in this list some measurements having their origin even at that elusive and indeterminate point the ophryon, if thereby the desired end shall be the sooner reached.

The number of measurements taken by the French and English is so large that the investigator is involved in a mass of calculations and tables that require an expenditure of time by no means commensurate with their importance. We recognize the fact that these measurements have a certain value, but we think that the principal facts regarding the size and proportions of the human cranium can be learned from not more than forty measurements and indices; doubtless certain crania will admit of unusual measurements, and a short supplementary list may be desirable, but the essential measurements should be taken in any case.[1] The French system is the oldest, and the system to be advocated should be based upon the *Instructions Craniologique* of Broca.[2] The successors of this distinguished anthropologist have improved upon the system as at first

[1] The number of measurements and indices taken by the different schools is shown in the following list:

Broca	84, Sur Les Cranes de la Caverne de l'Homme Mort. Paris, 1879. In the *Revue d'Anthrop.*, ser. 2, vol. v, p. 578, Topinard states that the number of measurements and indices used by Broca in his study of the crania of contemporary Parisians from the Cimitière de l'Oust was 103.
Topinard	65, *Éléments d'Anthropologie Générale*, p. 979. Paris, 1885.
Quatrafages	79, *Crania Ethnica*, p. 9. Paris, 1882.
Flower	57, *Journ. Anthrop. Inst.*, vol. ix, p. 107.
Duckworth	60, *Journ. Anthrop. Inst.*, vol. xxvi, p. 285.
Frankfort Agreement	42, *Archiv. f. Anthrop.*, Braunschweig, Bd. xv, s. 1.

[2] *Mem. Soc. d'Anthrop.*, 2d ser., 1875. Tome ii, p. 25.

outlined. The Germans, foremost among whom stands the venerable Virchow, have also grown away from the Frankfort agreement. The English, under the leadership of Sir William Flower, have based their work upon that of Broca. The Americans, without any leader devoting himself exclusively to somatology, have furnished some original contributions of no mean value.

The American Association for the Advancement of Science is to celebrate its semi-centennial at the coming meeting. The occasion will be fittingly observed, and it is hoped will be marked by the largest attendance in the history of the Association. The section of anthropology has always been one of the best attended, and most of those interested in somatology will probably visit Boston in August. Can we not take advantage of this opportunity to make the preliminary move toward a uniform system of craniometry? Such a congress meeting in this vicinity would have the further advantage of access to collections of crania and craniometrical instruments for purposes of illustration.

REVIEWS OF RECENT LITERATURE.

ANTHROPOLOGY.

The Aborigines of North-West-Central Queensland.[1] — The Australian aborigines are now ranked by ethnographers as fifth or sixth in the list of so-called natural races, the Veddahs of Ceylon being the lowest in the scale of savage culture. A few Anglo-Australians have appeared as earnest champions of the "Blacks," but the superior race commonly regards them as brutal and degraded, and the advent of the whites has been an even more disastrous event to the aborigines than in America. Disease, alcohol, and lead have rapidly reduced their numbers. A thorough and comprehensive study of the Australian tribes has never been attempted, and the information now obtainable from the miserable remnants of the race can afford us but an imperfect knowledge of their former condition. It is to be regretted, therefore, that such painstaking investigations as those of Dr. Roth were not made a century ago. The territory embraced in these *Ethnological Studies* is designated North-West-Central Queensland and lies beyond the region described by Lumholtz.

The book contains 184 pages of text, about one-third of which is devoted to the language of the twelve tribes that occupy that portion of the colony. The elementary grammar and the list of words selected for tabular comparison from the various dialects supply a much better basis for further linguistic study than the meager vocabularies previously published from that quarter. A vocabulary of about 600 words of the Pitta-Pitta dialect is given and about 200 more are included in the grammar. From the large number of vowel sounds we can easily believe the statements of other writers that the language is "soft, vocalic, and melodious."

We are led to infer that the sign-language is not very generally known to the whites, rather than that it is but rarely practised by the aborigines, as is stated by other writers. A recent authority declares that these northern tribes are more intelligent than those of South Australia. Another writer, however, asserts that the southern tribes are the more intelligent. The message sticks figured are inferior to those of East Australia. The remarkably complex nomenclature of

[1] *Ethnological Studies among the North-West-Central Queensland Aborigines.* By Walter E. Roth, Brisbane, Government Printer, 1897.

classes and individuals is described in detail and rendered more easily comprehensible by a table, or family tree. The decorative art of these people seems not to have passed that primitive form of expression exhibited in body painting; the patterns used are shown in color drawings. Rock paintings are almost unknown. The various kinds of vegetable and animal foods are enumerated and some account given of their preparation. No mention is made of those fruits and bulbs which in other parts of the continent are rendered innocuous by elaborate preparation before they can be used. We notice that the green ant is eaten raw. The method of capture differs somewhat from that in vogue elsewhere; instead of allowing the ants to crawl up a stick into the mouth of the hunter, he stamps upon the ant-hill until the ants run up his legs, when they "get scraped or swept off as fast as they come up."

A chapter is devoted to the subject of sports and festivals, including an account of the Molonga set of corroborees which require five nights for their completion.

The most interesting and valuable part of the work is that dealing with the medical practice and the superstitious rites and ceremonies of the aborigines. This sort of material is the most difficult to obtain from savages, or, for that matter, from people in any grade of culture. The subject of religion is not separately treated, and the incidental references are unsatisfactory and incomplete. Careful inquiries were made, but all the information obtained is summed up in a single sentence: "In his natural state, the fear of death is but as nothing to the savage; he has a hazy notion of the corpse 'getting older and moving about elsewhere' when he ceases to bring food and tobacco any longer to the burial-place; he has no dread of future punishment, no hope of reward in another life." Dr. Roth's professional training and familiarity with the Boulia language enabled him to thoroughly investigate the causes and results of the mutilations practised by these people; his conclusions tend to disprove the accepted theories accounting for the mika operation. The brief papers of Miklukho-Maclay and the accounts of other writers have given some information concerning these ceremonies and the sexual relation in general, but the present work is the most complete that has yet appeared.

A very full index and glossary is furnished. Drawings to the number of over 400 add materially to the value of the work, though the arrangement of the explanations of the plates at the beginning of the volume is not a convenient one.

GENERAL BIOLOGY.

Studies on Protoplasm.[1] — The author has here given a summary of her studies made during ten years upon protoplasmic phenomena. She recognizes that the study of living protoplasm, as opposed to preserved and tortured states, may to-day hope for some scattered sympathy. Her studies were unhampered by theory or predilection, except what may be described as a belief in life genii more complex and more potent than even surface tension and osmosis. The author has avoided controversial references, although arguing for Bütschli's foam theory of protoplasmic structure. The new facts brought forward, while not *explaining* phenomena, serve to *unify* them. The book contains 176 pages.

It is difficult to summarize this work, but certain main points may be noted. Not only is Bütschli's foam theory accepted, but it is extended by supposing, on the evidence of certain appearances which are described, that the walls of the alveoli of Bütschli are themselves made up of vesicles; and apparently their walls, in turn, may be vesiculated, and so on indefinitely. The continuous substance forming the walls of the vesicles is the true living matter, the material included in its spaces being merely passive.

The protoplasmic foam is found to have a structure in areas where the functions are chiefly vegetative which differs somewhat from the structure when the manifestations of contractility and irritability predominate.

The continuous substance is described as being commonly in a state of flux, or of active contraction. The spinning out of fine filose processes from protoplasmic surfaces was found to be of almost universal occurrence and is regarded by the author as of fundamental importance. These spinnings may be internal as well as external to the mass.

A "new structural formula for protoplasm" is given as follows (p. 106):

"Protoplasm is a very complex emulsion, having the physical arrangement of a very finely subdivided, variably viscid foam, which characters are coextensive with the continuous element of all visible optical reticula."

"The substance which at any given moment forms in all sub-

[1] The Living Substance: as Such: and as Organism. By Gwendolen Foulke Andrews. Boston, Ginn & Co., 1897. Supplement to the *Journal of Morphology*, vol. xii, No. 2.

divisions of the foam the continuous element varies its viscosity by some unexplained changes within its finer structure, so that from a fluid state it may almost instantly become viscid to varying degrees, even to a semblance of true solidity. It is subject to displacement by contraction activity which may be rhythmically organized or may be of a filose nature. . . .

"The continuous substance is at any given moment the physiologically active element of protoplasmic masses. . . . Upon its response in character of its powers, or properties, to specific and general environment depend all the physiological phenomena characterizing areas, masses, or organisms as such. It is homogeneous throughout all areas alike, as to its intrinsic powers and characters, but not as to the specific, or habitual, expression of these, which varies with its chemical or physical contacts."

The discontinuous elements, or protoplasmic inclusions, are heterogeneous in character and form the "specific environment" of the living substance. This is regarded by the author as the most important source of the stimulus which determines the course of protoplasmic activity.

The author's position in regard to the cell theory recalls the view of Wolff that the cell is not a fundamental unit, but merely an incidental expression of the vital activities of the continuous living substance. Although not expressed in these terms, she appears to agree with Driesch and Hertwig in regarding the differentiation of an area as a function of its position.

This is enough to give an idea of the scope and tenor of the book, which the reader, if not discouraged by a style which at times renders comprehension difficult, will find to contain much that is suggestive and interesting.

Isolation and Physiological Selection.[1] — Professor C. Lloyd Morgan has earned the gratitude of all biologists by completing the work so well begun by Romanes. The third and last volume of the *Darwin and after Darwin* was issued late in 1897. Of this the first two chapters and the last were in type at the time of the death of the author. The material in the remaining three chapters has been selected and arranged by Professor Morgan.

The first two chapters are devoted to a general discussion of the principle of isolation. "Equalled in its importance by the

[1] G. J. Romanes, *Darwin and after Darwin; III, Post-Darwinian Questions: Isolation and Physiological Selection.* Chicago, Open Court Pub. Co., 1897.

two basal principles of Heredity and Variation, this principle of Isolation constitutes the third pillar of a tripod on which is reared the whole superstructure of organic evolution." Natural Selection is regarded as merely a special case of isolation when the best fitted are separated from the less fit by the death of the latter. The following chapters are concerned with another special case of isolation, namely, Physiological Selection. Here are brought together in convenient form the chief facts and arguments in regard to this important subject. This is followed by a chapter giving a brief history of the opinions on isolation as a factor of organic evolution, and the general conclusions of the whole work are summed up in a final chapter.

The book is largely controversial in tone, and the arguments are presented, of course, from the standpoint of the well-known views of the author. Still, the other side is at least given a hearing, and we have in the three volumes as a whole what we have not had before, — a complete work on organic evolution reflecting the thought of recent times.

ZOOLOGY.

A Viviparous Holothurian. — The life histories of the few holothurians that protect their young during the early stages of their development afford some most peculiar and interesting instances of adaptation, as regards both structure and habits.

The transference of the eggs in *Cucumaria planci* to an atrium in front of the mouth and encircled by the tentacles, there to be fertilized by spermatozoa thrown out by a neighboring male into the surrounding water, which is swept into the atrium by the movements of the tentacles of the female, is well known from Selenka's account of the process.

We are also acquainted with the conditions in *Cucumaria glacialis* Ljungman in which Mortensen[1] describes a pair of broad pouches, invaginations of the body wall in the ventral interradii, immediately behind the circle of tentacles. The large yolk-filled eggs (diam. 1 mm.) after being laid are presumably taken up by the female from the sea bottom into the pouches. Similar brood sacs are found in another Arctic species, *Cucumaria minuta* Fabr., and in *C. laevigata* Verr. of the Antarctic seas.

[1] Th. Mortensen, Zur Anatomie und Entwicklung der Cucumaria glacialis (Ljungman). *Zeit. f. wiss. Zool.*, Bd. lvii, pp. 704–732, Taf. 31, 32. 1893.

Another curious adaptation has been described by Ludwig[1] in *Chirodota contorta* Ludw., also from the Antarctic. In this animal the reproductive tubules themselves serve as receptacles for the young until they have attained a length of 3 mm. or more, when birth takes place through the outer opening of the genital duct.

Furthermore, the attachment of the eggs of *Cucumaria crocea* Less. and of *Psolus ephippifer* W. Thoms. to the dorsal surface of the mother, where the young are reared, is a fact that is familiar to all naturalists.

In still other holothurians the eggs have been known to find their way in some hitherto unexplained manner into the body cavity, where they develop. One of these forms is *Synapta vivipara*, originally described by Oerstedt from specimens taken in the West Indies. It is probably identical with Theél's *Synapta picta*, which the Challenger Expedition took at the Bermudas.

Synapta vivipara has recently been thoroughly studied by Dr. Hubert Lyman Clark[2] in the Johns Hopkins Marine Laboratory at Port Henderson, Jamaica. It is to be found in the quiet pools in the rear of Port Royal, clinging to the red seaweed Acanthophora, which is attached to the roots of the mangroves.

The eggs probably burst through the thin walls of the bisexual reproductive tubules into the body cavity; they were never observed in the genital duct, nor were passages from it into the body cavity discovered. The duct runs forward into the body wall, but ends blindly in the connective tissue beneath the external epithelium.

Spermatozoa were found abundantly both in the duct and in the connective tissue about its blind end; hence it is believed that they pass outward through the epithelium of the end of the duct, the connective tissue layer, and the thin external epithelium of the body wall. Thence they are believed to make their way to another individual, and by passing inward through the anus and certain apertures in the walls of the rectum into the body cavity they meet the ova.

Apparently ripe spermatozoa and ova occur simultaneously in the same reproductive tubule, but there is nothing to indicate that the spermatozoa ever pass from its lumen through its wall into the body cavity. Indeed, no direct evidence has been obtained to show either that self-fertilization does or that it does not take place in *Synapta vivipara*.

[1] H. Ludwig, Ein neuer Fall von Brutpflege bei Holothurien. *Zool. Anz.*, Jahrg. xx, Nr. 534, pp. 217–219. 1897.

[2] H. L. Clark, Synapta vivipara: A Contribution to the Morphology of Echinoderms. *Memoirs Bost. Soc. Nat. Hist.*, vol. v, No. 3. 1898.

H. L. Clark, The Viviparous Synapta of the West Indies. *Zool. Anz.*, Jahrg. xix, Nr. 512, pp. 398–400. 1896.

Without considering in detail the development of the larvæ, we will discuss certain features of the process which are of such especial interest as to merit the attention of the general reader.

The ciliated gastrula which swims freely in the body cavity of the mother presently becomes transformed into an oval embryo without ciliated bands; a mouth at this stage is found upon the ventral surface of the body, but there is no anus; the blastopore has closed. A pair of cœlomic pouches are present, as well as a hydrocoel, which has upon its anterior face five large interradial outgrowths (the canals of the primary tentacles) and five smaller *radial* outgrowths, each of the latter being situated at the right of one of the former. An *adradial* water canal opens upon the surface of the body by a dorsal pore.

Thereupon follows a *pentactula* stage in which the hydrocoel, its extremities having united near the mid-ventral line, forms a ring; a Polian vesicle is present in the left-dorsal interradius; the central nervous system has been established, the nerve ring having been derived from a thickening of the ectoderm which surrounds the mouth, the radial nerves, as well as nerves to the tentacles, having arisen as outgrowths from the circular nerve band; five pairs of otocysts lie external to the radial nerves at the point where they bend to run backward; the mouth, situated in the center of a circle of tentacles, opens into an œsophagus lined with endoderm; the stomach is large; the intestine makes a single loop; an anus is now present at the posterior extremity of the body; a mesentery, formed by the fusion of the right and left cœlomic pouches, attaches the alimentary tube throughout its whole extent to the body wall.

The pentactula then becomes transformed directly into the larva with ten tentacles which, when it has attained a length of about 5 mm., is set free from the parent. In some cases, however, young individuals 15 mm. or 20 mm. in length have been observed still within the body cavity of the mother. Birth takes place by the rupture of the body wall near the anus, or, more frequently, by a perforation through the wall of the rectum, in which case the young finally escape through the anal opening.

The most striking feature of the abbreviated course of development of *S. vivipara* is the complete lack of radial water canals of the body wall, even in the embryo. It seems to be definitely determined[1] that in *S. digitata* these canals are formed in the early stages of

[1] R. Semon, Die Entwickelung der Synapta digitata und die Stammesgeschichte der Echinodermen. *Jena. Zeit.*, Bd. xxii, pp. 175–309, Taf. 6–12. 1888.

development, and it is equally certain that in the adult of this same species, as well as in many or all other Synaptidæ, they are entirely lacking.[1] In *S. vivipara* the five primary interradial outgrowths of the hydrocoel grow forward and constitute the canals of the five primary tentacles; the five secondary radial outgrowths extend forward, each to a point immediately in front of which a radial nerve passes outward in its course to the body wall. From three of the radial outgrowths of the hydrocoel branches soon arise, which grow forward on either side of a radial nerve and form the basis of the accessory tentacles; from the fourth or left-dorsal radial outgrowth a single branch arises, ventral to the radial nerve, forming an accessory tentacle of the left-dorsal interradius; whereas the fifth or mid-ventral outgrowth is never more than a slight protuberance, from which no accessory tentacles are normally developed, and which usually soon atrophies and disappears. None of the radial outgrowths of the hydrocoel is prolonged to form a radial canal in the body wall.

From the fact that no radial canals are ever developed in *S. vivipara* it is evident that we have in this form a more degenerate condition of the water vascular system even than in *S. digitata*. The fact that the stone canal in the adult *S. vivipara* has an opening directly upon the surface of the body, with a madreporite near the body wall having openings into the cœlom, would seem to indicate, on the other hand, that in this one particular the water vascular system has retained its primitive structure.

When, furthermore, we compare the water vascular system of the larva of *S. vivipara* at the stage with ten tentacles with that in Cucumaria at a similar stage, as described by Ludwig,[2] we find strikingly similar conditions. If the Synaptidæ have been derived, as Ludwig has suggested, from an ancestor the tentacles of which arose as branches from five radial outgrowths of the hydrocoel, and if we should, furthermore, suppose that subsequently by the gradual shortening of those outgrowths the five primary tentacles came eventually to arise directly from the hydrocoel ring, losing their immediate connection with the radial outgrowths, then we would have a complete homology between the conditions which Dr. Clark has found in *S. vivipara* and those in Cucumaria as described by

[1] H. Ludwig und P. Barthels, Zur Anatomie der Synaptiden. *Zool. Anz.*, Jahrg. xiv, pp. 117–119. 1891.

[2] H. Ludwig, Zur Entwickelungsgeschichte der Holothurien. *Sitzungsber. k. preuss. Akad. Wiss.*, Nr. 10, pp. 179–192; Nr. 32, pp. 603–612. 1891.

Ludwig. Unless this assumption is made, however, the evident correspondence between the secondary tentacles of the two forms which Dr. Clark has pointed out would mean nothing, because the primary tentacles would not be homologous.

This entire assumption is plausible for these reasons: (1) there is an evident degeneration of the water vascular system of the Synaptidæ which would be expected to affect first the primary tentacles; (2) the primary tentacles can more easily be supposed to have originally sprung from radial canals than *vice versa*, since the secondary tentacles, in fact, are known to arise from radial canals, whereas there is little evidence in favor of the view of Semon that the tentacles in the primitive holothurian arose directly from the circular water canal.

An abundance of anatomical and histological evidence could be given to show that the Synaptidæ are more closely related to the Molpadiidæ (*e.g.*, Caudina) and their allies the Cucumariidæ than to any other groups of holothurians. Hence we may, as suggested by Ludwig, regard these three families as forming one of the two great branches of the family tree of the holothurians.

While the Synaptidæ retain some primitive characteristics, as, for example, hermaphroditism, they are in many respects highly specialized forms, particularly as regards sense organs. Otocysts, containing a single vesiculated cell, and sensory papillæ upon the surface of the body and the abaxial surface of the tentacles are described in *S. vivipara.* The ganglia found by Cuénot[1] at the base of these papillæ in *S. inhaerens* O. F. Müller have been observed also in *S. vivipara.* The structure of similar ganglia in *S. girardii* Pourtalès and *S. roseola* Verr. of our own coast has lately been investigated with methylene blue by the present writer.

When the larva has still only ten tentacles a pair of "eyes" appear in the connective tissue at the base of each tentacle, and later, when the last two accessory tentacles appear, one in each lateral dorsal interradius, another pair of eyes is formed at the base of each of them. A knob-shaped protuberance grows out from the side of each tentacular nerve, where it arises from the nerve ring, into the connective tissue, and becomes covered with a layer of mesenchyme cells. This mesenchymatous covering in the adult consists of a "rather horny" layer of light brown color, containing scattered nuclei; it is continuous with a thin mesoderm layer which is said to surround all the

[1] L. Cuénot, Études morphologiques sur les Echinodermes. *Archives de Biol.*, tome xi, pp. 313–680, Pl. XXIV–XXXI. 1891.

nerves; this covering becomes transformed into a thick, pigmented, lens-like structure. The "eye" proper consists of vacuolated cells of a prismatic shape; each is swollen at the free end and tapers at the other extremity, at which it is continuous with a nerve fiber.

It is remarkable that in *S. vivipara* no true sensory buds, the cup-shaped structures that are found in many Synaptidæ attached to the axial surface of the base of the tentacles, were discovered.

Nerves which supply the œsophagus and mouth region in *S. vivipara* are described. Similar nerves in *Caudina arenata*, ten in all, were investigated by the present writer.[1] These nerves have been observed in several other holothurians not noted by Dr. Clark, and in view of their widespread occurrence it is not improbable that they may yet be found in most, if not in all, holothurians.

In our brief consideration of this interesting holothurian we have noted the degeneration of the genital duct, the thinness of the walls of the reproductive tubules, and the apertures through the wall of the rectum, — all adaptations parallel with a most peculiar manner of protecting the young; we have considered the marked degeneration of the water vascular system, no radial canals being found even in the larva, and the significant fact that the tentacles in part spring from radial outgrowths of the hydrocoel, as in Cucumaria and Caudina; and, finally, allusion has been made to some features of certain sense organs which are found not only in *Synapta vivipara*, but also in other Synaptidæ.

JOHN H. GEROULD.

DARTMOUTH COLLEGE, HANOVER, N. H.

Shufeldt's Chapters on Natural History.[2] — The first thing which strikes one in opening this volume is the beauty of many of the illustrations, most of them half-tone reproductions of photographs direct from nature. Dr. Shufeldt has long advocated this method, and the results here presented fully justify his contention. There is a life to these illustrations which is lacking from even the best of products of pencil and brush; the artist represents the animal as he thinks it ought to look; the camera represents the animal itself. To us the best of the illustrations are that of the common swift (Sceleporus), those of the green snake and king snake (*Cyclophis vernalis*

[1] J. H. Gerould, The Anatomy and Histology of Caudina arenata (Gould). *Proc. Bost. Soc. Nat. Hist.*, vol. xxvii, pp. 7–74, 8 pl. 1896. Also *Bull. Mus. Comp. Zool.*, vol. xxix, pp. 121–190, 8 pl.

[2] *Chapters on the Natural History of the United States.* By R. W. Shufeldt, M.D. Studer Brothers, New York, 1897. 8°, pp. 472 [+ 8].

and *Ophiobolus rhombomaculutus*), and the first of the cedar bird. The text tells us of the trials necessary in order to get such results, and every amateur in photography knows that not every plate exposed can produce negatives equal to even the poorest in the volume. With such illustrations as a rule, it is a pity that there should be others in the volume, drawn by the author, of a decidedly lower standard.

Judging from the statements made in the first chapter, the text is intended primarily for younger readers, but the author has not been very successful in writing up (or down) to his constituency. In places he explains at some length points which every boy knows, while in others he assumes a knowledge on their part of facts which of course are familiar to those who, like the author, have spent years in scientific study. Then the book in many places sets a bad example to the young in the way of faulty English, while the proof reading is poor, battered letters, wrong fonts, and bad punctuation and capitalization disfiguring the otherwise fine pages. Again, there are many statements open to question. Thus, on page 146, speaking of the turtles, our author says: "It is with the Batrachia only that they can claim any affinity, as is shown by their structure. From all other existing reptiles they are clearly distinguished by the hard osseous shell that encases their bodies. . . ." On page 74 the statement is made that only two specimens of the rare shark Chlamydoselachus have come into the hands of science. Garman had one; Günther had three specimens when preparing his account in the "Challenger" report. In 1890 a specimen was found off the Madeira Islands, and in 1896 one was found off northern Norway. Besides these, the Japanese have obtained several additional specimens, and as we write we find specimens quoted at about sixty dollars in the catalogues of dealers. Among minor faults, we notice the use of the name Muraenopsis, although years ago Ryder pointed out that this genus had no validity. Fig. 106 should have been credited to Elliott. The trinomial nomenclature introduced here and there is unnecessary, and in the abbreviated form in which it occasionally appears (*e.g.*, *L. g. getulus*) it will be more than confusing to the beginner.

Aside from such shortcomings as those instanced, the volume has the materials for a good book. There is a demand for books which will interest the young in just those lines of study which are sorely neglected in our ordinary text-books. The old-time naturalist had his faults, but he had also his merits, and it is greatly to be regretted

that he is passing away. Books built on lines like those which Dr. Shufeldt follows will tend to render the time of his total extermination far distant, and, in case a second edition of this work is called for, we hope that it will be developed largely on the model shown in the chapter on bats, to our mind the best chapter in the whole work. It would be well in a second edition to omit the final chapter on museums, which, as it now stands, has no *raison d'être.*

Origin of the Cleavage Centrosomes. — Boveri, in 1887, was the first to prove that the centrosome which gives rise to the centrosomes of the first cleavage spindle is brought into the egg by the spermatozoön. This observation, made on the egg of Ascaris, led to the formulation of the following conclusion by Boveri: "The ripe egg possesses all of the organs and qualities necessary for division excepting the centrosome, by which division is initiated. The spermatozoön, on the other hand, is provided with a centrosome, but lacks the substance in which this organ of division may exert its activity. Through the union of the two cells in fertilization all of the essential organs necessary for division are brought together; the egg now contains a centrosome which by its own division leads the way in the embryonic development."[1]

Additional evidence was soon furnished by Vejdovsky, who, in the case of Rhynchelmis, followed the disappearance of the egg centrosome, a thing which Boveri had not actually done. Fol, however, in 1891, described the remarkable process in the echinoderm egg, which he called the "Quadrille of Centers," and maintained that the egg centrosome and sperm centrosome divide, each into two, the daughter centrosomes then conjugating, a maternal with a paternal one, to form the two centrosomes of the first cleavage spindle. His paper was generally accepted, in spite of the earlier work on the subject, and was confirmed by the results of Guignard, Conklin, Blanc, Van der Stricht, and Schaffner. Belief in the existence of the "quadrille" was destined to be dissipated in the light of later research, and a score of investigators have definitely proved its mythical character; among these may be mentioned Fick, Wilson and Mathews, Mead, Boveri, Hill, Rückert, Reinke, Kostanecki and Wierzejski, Sobotta, and several others. A return has, therefore, been made to Boveri's original contention that the cleavage centrosomes are derived solely from the sperm centrosome, and, as the

[1] *The Cell in Development and Inheritance.* By E. B. Wilson. New York, 1896, pp. 141, 142.

observations extend over a very wide range of forms, the applicability of the view to the whole animal kingdom has been generally accepted.

There has been one discordant account, however, since Wheeler, in 1895, published a preliminary paper[1] in which he maintained that in the case of *Myzostoma glabrum* the egg centrosome persists and divides to form the cleavage centrosomes. This observation, coming from such an able investigator and being supported by the unqualified statement that no trace of centrosome or archoplasm could be detected in connection with the sperm nucleus, carried with it great weight; but, as it stood a solitary exception to the recent work on the subject, criticism was for the greater part suspended until a more detailed description had appeared. His completed paper[2] has recently been published, giving additional figures and stronger evidence in support of his position. One would have accepted his results unhesitatingly, had it not been for the fact that there has since appeared a paper[3] by Kostanecki, who has worked on the eggs of the same species, *M. glabrum*, and arrived at conclusions absolutely at variance with Wheeler's. This investigator is unable to find any persisting egg centrosome, which, he states, utterly disappears after the extrusion of the second polar body, but he does see a small, clear, archoplasmic area lying close to the side of the sperm nucleus, and containing one or two centrosomes and later distinct radiations. This sperm aster by division forms the amphiaster of the first cleavage, and the author concludes that Myzostoma presents no exception to the view of Boveri. It is unfortunate that Kostanecki had not seen Wheeler's final paper before the publication of his own work, as much of his criticism of the latter's figures in the preliminary note is destroyed by the more detailed description and by new and clearer figures in the later account.

In regard to the maturation processes, the two authors are in agreement on essential points, but it might be mentioned that Wheeler was only able to find a "Zwischenkörper" in the second polar mitosis, while Kostanecki states that he has seen it in the first as well, although he does not figure it.

After the formation of the polar bodies and the two re-formed vesicular pronuclei have begun to approach each other, there is a period when neither Wheeler nor Kostanecki has discovered in many

[1] *Journ. Morph.*, vol. x, No. 1, 1895.
[2] *Archiv. de Biol.*, tome xv, fas. 1. 1897.
[3] *Archiv. f. mikr. Anat.*, Bd. li, Heft 3. 1898.

eggs any trace whatever of centrosome or archoplasm in connection with either nucleus. In more favorable sections at this stage, however, an archoplasmic field, very faint at first, but later showing centrosomes and radiations, is observed by Wheeler lying close to the egg nucleus, but no indication of such structures is found near the sperm nucleus. Kostanecki's observations, on the other hand, are precisely the reverse, the centrosome and archoplasm, when visible at all, being seen just outside the membrane of the sperm nucleus, while nothing of the kind accompanies the egg nucleus.

Here we are confronted by totally contradictory observations of two able investigators, working on the eggs of the same species of animal, and until one or the other author is confirmed by future study of the fertilization of the egg of *Myzostoma glabrum* judgment in this case will have to be withheld.

The doubt which Wheeler's work, of late the sole remaining contradiction, has seemed to cast on the universal validity of Boveri's view throughout the animal kingdom is, at all events, greatly diminished by the recent publication of Kostanecki.

GEORGE LEFEVRE.

Plankton Studies on Lake Mendota.[1]—This paper, being a report of the continuation of Professor Birge's work on Lake Mendota, is by far the most important American contribution, to our knowledge, of the biology of lakes. It contains the results of observations and collections made at maximum intervals of two weeks during a period of two years and a half. These observations have been worked out with infinite care and patience, and the conclusions are of very great interest. The author does not maintain that the conclusions are in all cases final, as, indeed, that would be impossible, because of the very complex character of the problems attacked. But he certainly is to be congratulated on the amount he has been able to accomplish.

It is impossible for a reviewer, within any reasonable limits, to treat of the paper, for, while it is a somewhat bulky production — covering 174 pages of the eleventh volume of the *Transactions of the Wisconsin Academy* — it is really so much condensed that one cannot make an abstract of its contents. All that can be attempted is to indicate the subjects treated.

After a brief discussion of the methods employed in the investigation, the divisions of the paper are taken up in the following order:

[1] Plankton Studies on Lake Mendota. II. The crustacea of the plankton, July, 1894–December, 1896. By E. A. Birge, Professor of Zoology in the University of Wisconsin. *Trans. Wisconsin Acad. Sci.*, vol. ii.

temperature, annual distribution of crustacea, with a discussion of the factors controlling annual distribution, vertical distribution, and a discussion of the factors controlling vertical distribution.

In treating of temperature, Professor Birge proposes the term *thermocline* as the equivalent of the German *Sprungschicht*, a happily chosen word, which will, doubtless, have a permanent place in scientific nomenclature. The thermocline is that layer of water in which there is a sudden change from the warm temperature of the surface to the cooler temperature of the lower waters. The thermocline lies at a depth of from eight to ten meters, and at this point there may be a change of as much as nine degrees in a single meter. The position of the thermocline is somewhat variable, being determined not simply by convection, as is intimated by most German authors, but also by the effect of the wind. It follows that the thermocline will be higher in a lake protected from the winds than in a larger body of water.

The author then gives a detailed account of the annual distribution of the forms of crustacea found in Lake Mendota. His results are not entirely in accord with the observations of European authorities or with those of the reviewer in Green Lake. It is perhaps remarkable that the agreement should be as great as it is, when we consider the differences in environment of the lakes.

The factors of annual distribution are stated to be food, temperature, and competition. It follows because of variations in the amount of food and the yearly changes of temperature, with a general correspondence between successive years, that there are yet marked differences. He finds evidence of competition in the fact that certain species are predominant at times to the exclusion of others, this being explained on the assumption that the water can support only a certain number, and that the first species that gains control of the field will inevitably exclude others.

In speaking of the vertical distribution of crustacea, he records observations on the migration in the upper meter, finding evidence of a very distinct diurnal migration within narrow limits. He finds, too, that the thermocline seems to be the lower limit of the vast majority of crustacea, only a few forms being found in abundance below that point.

In the account of the vertical distribution of individual species there are many interesting facts. He finds the distribution of Diaptomus very different from that reported of the Diaptomi of Green Lake. This does not seem to me strange, for the Diaptomus

of Mendota is *D. oregonensis*, while that of Green Lake is *D. minutus*, a species of very different habits. It should be noted, too, that the Diaptomi are especially susceptible to the influences of the environment, and we must expect the different species to have their own peculiarities.

He enumerates eight factors which determine vertical distribution, *viz.*: (1) food, (2) temperature, (3) condition of water in regard to dissolved oxygen and other substances, (4) light, (5) wind, (6) gravity, (7) the age of members of any given species, (8) specific peculiarities.

Of these factors, the third is one of great importance, which has received very little attention from preceding authors. Professor Birge states that he is unable to state whether the lack of life in the lower waters of Mendota is due to a lack of oxygen or to a large amount of the products of decomposition. It has seemed to the reviewer that it was very probable that the products of decomposition have very much to do with the lack of life in many lakes, for, in an examination of a number of the Wisconsin lakes during the last summer, it was noticed that the deep lakes of small area had a large amount of organic matter on the bottom and almost an entire lack of animal life, while in the larger lakes with less organic matter there was a considerable abundance of animals. The other factors are discussed with considerable fullness. It is shown that gravity has a marked influence on the vertical position of crustacea, as it is only by considerable effort that they maintain their vertical position, and that, as they grow old or are enfeebled for any cause, they gradually fall to lower levels. Under seven it is shown that the young crustacea appear in greater numbers near the surface. The young of the copepods form an exception, however, for they appear in the greatest numbers near the thermocline.

In conclusion, the reviewer must again express his regret that it is impossible to do justice to the paper within the limits of ordinary review, and considers that he has done as well as could be expected if he has succeeded in making evident the value of the investigation.

BOTANY.

Lessons with Plants.[1] — In recent years there has been a great multiplication of books designed to render the study of botany attrac-

[1] *Lessons with Plants: Suggestions for Seeing and Interpreting Some of the Common Forms of Vegetation.* By L. H. Bailey. With delineations from nature

tive to the general reader. Albeit some of these have contained a good many questionable statements, they have all ministered more or less directly to an increasing popular demand for simple, non-technical presentations of scientific themes. During the same time there have been many attempts to prepare text-books of botany for common schools and grammar and high schools, the aim of each being to combine simplicity with exactness of statement. Some of these books have been very good, but none of them have occupied quite the field of the one before us.

This book occupies a sort of middle ground. It is not strictly a botany, at least not in the old technical sense, but rather a delightful book about plants, — a series of nature studies designed to interest all sorts of people, old and young, teachers, preachers, laymen, and students. Mothers who wish to teach their children something about plants and do not know how to begin will find this book very useful. The same may be said of a large class of teachers in our public schools. At the same time, it will prove a pleasant companion for persons who are neither parents, teachers, nor botanists, but who have a leisure hour now and then for rambles and wish to know something about the plants they meet.

The first sentence of the introduction sets the pace for the whole book: "Plants are among the most informal of objects, but botany is popularly understood to be one of the most formal of the natural sciences. This is only another way of saying that plant study is not always taught by a natural method."

The book is exceedingly attractive in appearance and a perusal of its contents in no way lessens the first impression. It is interesting from beginning to end, even to a professional botanist, who might be pardoned some weariness over details of things long familiar. The aim of the book is to cultivate the reader's faculty for observation and his ability to reason correctly on what he has seen. Some of its suggestive statements will bear quotation: "The lesson to be derived from this discussion is not what particular interpretation has been placed upon certain facts, but that there is endless variety, and that every fact and phenomenon must be investigated for itself." Again: "In making such studies as those recommended in the last paragraph, both teacher and pupil should consider that mere identification is not the end to be sought. It is always a satisfaction to know the names

by W. S. Holdsworth, Assistant Professor of Drawing in the Agricultural College of Michigan. Macmillan, New York, 1898. xxxi + 491 pp., with 446 illustrations.

of plants, but the important results, from the educational point of view, are the awakening of sympathy with natural objects, the sharpening of the powers of observation, and the strengthening of the faculty of reasoning from the object to laws and principles." And once more: "The collecting of natural objects is one of the delights of youth. Its interest lies not only in the securing of the objects themselves, but it appeals to the desire for adventure and exploration. Botanizing should be encouraged; yet there are cautions to be observed. The herbarium should be a means, not an end. To have collected and mounted a hundred plants is no merit; but to have collected ten plants which represent some theme or problem is eminently useful. Schools usually require that the pupils make an herbarium of a given number of specimens, but this is scarcely worth the effort. Let the teacher set each collector a problem. One pupil may make an herbarium representing all the plants of a given swale, or fence-row, or garden; another may endeavor to show all the forms or variations of the dandelion, pigweed, apple tree, timothy, or red clover; another may collect all the plants on his father's farm, or all the weeds in a given field; another may present an herbarium showing all the forest trees or all the kinds of fruit trees of the neighborhood, and so on."

The style of the book is very clear and often remarkably vivid. Occasionally a whole landscape is crowded into a line or two, as in the following: "Most persons are familiar with the flowering dogwood, the small twisted-grained tree which hangs its pink-white sprays against the woodlands in early spring."

All of the illustrations are original, many are excellent, and some are very unique and attractive, *e.g.*, the group of dandelions, the mayflower, the hepaticas, the turnip field showing "a battle for life." The book has a full table of contents, a register of illustrations (to which most of the Latin names are relegated), a glossary, and a good index. The body of the work is divided into parts, chapters, and numbered paragraphs, so as to make it very convenient for use. The introduction tells how the book may be used and how it came to be written. The first part of the text proper is devoted to studies of twigs and buds. This is followed by studies of leaves and foliage, studies of flowers, studies of fructification, studies of the propagation of plants, studies of the behavior and habits of plants, studies of the kinds of plants, and an appendix containing suggestions and reviews. It is not forgotten that country schoolhouses are usually forlorn places, and some pages and several pictures are devoted

to showing how the grounds may be made more attractive at slight expense.

Throughout the book the fact is kept constantly before the mind that plants are not fixed and unchangeable objects, but very plastic, gradually changing with changing conditions. Perhaps no text-book ever written is more successful in this respect. "The present forms of vegetation, then, are the tips of the branches of the tree of life. Therefore, the 'missing links' are to be sought behind, not between: they are ancestors, not intermediates." Again: "We really cannot understand plants by interpreting them solely upon their present or obvious characters; the reasons for the appearing of given attributes should be sought in the genealogy, not in the present-time characteristics. It is possible that many of these structures which seem to us to have arisen for the purpose of dispersing the seeds may have originated as incidental or correlative structures, and that it merely so happens that they serve a special but incidental purpose in disseminating the plant. If we once assume that every feature of a plant is adapted to some specific purpose, and that it has arisen by means of the effort of the plant to adapt itself to such purpose, we are apt to find adaptations where there are none. We are really throwing our own thoughts and feelings into the phenomena; and we are developing a superficial method of looking at nature."

Occasionally one notices such slips as are inseparable from first editions, but the errors are remarkably few and of such a nature as to admit of easy correction in the next edition, which we understand is already in preparation. Undoubtedly, the book will open the eyes of a great many people to the delights of meadows and woodlands, and also to the many interesting things that may be found even in a window garden or in the smallest dooryard. It deserves to have a very wide reading, and it is not too much to wish that it might find its way into the hands of a majority of the teachers in our common schools.

Erwin F. Smith.

Morphology and Development of Astasia asterospora and Bacillus tumescens. — In recent years several well-known writers, like Bütschli, Fischer, and Migula, have given us their views on the bacterium cell. Since these writers do not agree as to the structure and nature of all the parts, Arthur Meyer[1] has made a careful study

[1] *Studien über die Morphologie und Entwickelungsgeschichte der Bacterien, ausgeführt an Astasia asterospora A. M. und Bacillus tumescens Zopf.* Flora, **84**: pp. 186–248, pl. 6.

of the life history and morphology of *Astasia asterospora* A. M. and, incidentally, *Bacillus tumescens* Zopf. The paper, in addition to its value as a morphological study, contains many interesting details on methods of staining to differentiate different parts and clearly bring out the structure of the spores, nucleus, vacuoles, and mucilage.

The organism was obtained from boiled carrot and isolated by heating the spores to 90° C. for three minutes. On sterilized carrots, a gray, lustrous, gelatinous mass grows along the line of inoculation, and in five days spreads over the whole surface, with numerous gas bubbles. Other culture media used were as follows: peptone cane sugar solution, asparagine solution, peptone meat extract. In cane sugar solution, the organism produced 25-60 per cent of carbon dioxide, the remainder being a combustible gas, chiefly hydrogen. In a normal nutrient solution, the medium became cloudy in fourteen to eighteen hours. During this period the rods are actively motile (period 1). Motility ceases in twenty-four hours, small masses of bacteria occur, and some gas is formed. The former increase in size, becoming large and flaky, and rise to the surface with the contained gas. In fifty hours gas development has ceased entirely. The end of the period occurs in forty-eight hours (period 2). In forty-eight hours the gelatinous flakes drop to the bottom of the flask, and spores are abundant (period 3). In sixty-four hours isolated ripe spores occur (period 4).

The author determined that it does not produce a diastatic ferment capable of dissolving starch, nor one that is capable of reducing cane sugar, but in all probability an enzyme is formed which acts upon cellulose, since the middle lamella of the cell wall of carrot is dissolved. It is also an acid-producing organism; the amount is greater in normal nutrient solution than when grown in asparagine solution.

The morphology and development of Astasia may be summarized as follows: The spore germinates in a normal nutrient solution, when kept at 30° C., in about six hours. The rod coming from the spore is at once motile; by repeated subdivisions other rods are formed. In the course of twelve hours single motile rods cease to move, and the development of mucilage proceeds. One may also notice that motile masses move through the medium, and these approach a mass and leave it again. This is kept up till the "swarmer" becomes inactive. In this way round colonies are formed and with the contained gas rise to the surface, where they collect as mucilaginous flakes. Generally the Astasia occurs as a

single rod. Rarely are the rods placed end to end, forming a thread imbedded in mucilage. Mucilage is not formed by the transformation of the cell wall. Meyer further demonstrates that an abundance of mucilage is formed between the two rods in the process of cell division, but is difficult to demonstrate during the early stages. In the motile stages it occurs only between the two rods, but in the resting stage mucilage rapidly surrounds the whole organism. It may be noted, also, that a protoplasmic band connects the two rods in Astasia and some other species examined. It is probable that protoplasmic connection will be found in bacteria where rods form chains, or in motile forms which consist of several rods. The bunched flagella are lateral, and occur singly or a pair near the end, and occasionally a third bunch below. The third bunch, in most cases, occurs before division. Vacuoles may be made out in stained as well as unstained preparations, and these are axillary, much like those of Eumycetes. These differ in form as well as number. The Astasia vacuole was compared with that of Hypomyces, in which glycogen was found. The vacuole of dried Astasia preparations stains readily, the peripheral portion more intensely than the cytoplasm. It is to be expected that the vacuoles of bacteria should often contain concentrated reserve material.

The bacterial protoplast has some further points of similarity with Eumycetes. It has one or more nuclei in the cell, but not Bütschli's nucleus. Bütschli considers that a "Centralkörper" is the main part of the protoplast, and that cytoplasm is reduced to a minimum. Meyer's nucleus is a much smaller body. With staining reagents it behaves like the nucleus of fungi. In cell division the cytoplasm contracts, and a nucleus passes into each part. In one hour a new cell is formed, each rod containing a nucleus. The nucleus is not connected with the formation of the cell wall. *Bacillus tumescens* forms its spores in the same way that Astasia does. One-half of the cytoplasm of the sporangium becomes clearer, the other half granular. In a short time the somewhat more refractive fertile cytoplasm of the sporangium contains a nucleus, and the whole is separated from the homogeneous plasma by a delicate line. The young spore refracts light strongly. A wall forms about it, and at maturity it is provided with two walls. In Astasia the outer wall (extine) is provided with projections and the intine is smooth. A strongly refractive rod may also be observed in the interior. The method of spore formation in these species may be compared with that taking place in Ascomycetes. Astasia, however, never branches,

but perhaps true branching occurs in some species closely related to this organism. Motile masses are never produced by the Ascomycetes, a difference that constitutes a valid point of separation. Meyer discusses the relationship of Schizomycetes to this group, and proposes the following classification of the

BACTERIACEÆ.

BACTERIEÆ. Cells motionless. *Bacterium.*
BACILLEÆ. Flagella arising from the whole surface. *Bacillus.*
PSEUDOMONATEÆ. Flagella polar.
(*a*) Normally with a single flagellum. *Bactrineum.*
(*b*) Normally with more than one flagellum. *Bactrilleum.*
ASTASIEÆ. Flagella in groups, lateral.
Flagella in one or two groups, one-celled rods. *Astasia.*

L. H. PAMMEL.

Brown Rot of Cruciferous Plants. — Erwin F. Smith, who has made an exhaustive and careful study,[1] concludes that *Pseudomonas campestris* is responsible for the brown rot of cabbage and other cruciferous plants. There certainly seems to be no doubt that the organism described somewhat briefly by the writer several years ago is identical with that described by Smith. It produces a distinct browning in the bundles, the bacteria having a fondness for the alkaline sap of the bundles and little attraction for the acid parenchyma. Infections were obtained by needle punctures, by means of slugs and insect larvæ, and through the water pores situated on the teeth of the leaves. Infections through ordinary stomata were not obtained; the waxy bloom on the cabbage leaf protects the plant. It is probable that a majority of the natural infections in the field take place above ground, the disease being transmitted from diseased to healthy plants and from one part of a plant to another, as the result of the visits of insects and other small animals. The organism grows well in feebly alkaline beef broth. Gelatin is slowly liquefied. In addition to these media, Smith cultivated it on cabbage broth, litmus cabbage broth, agar, potato, carrot, beet, onion slices, orange segments, cocoanut flesh, etc. In cruciferous substrata it grew promptly and with great vigor, except on the horse-radish, where the growth at first was slow. On steamed cauliflower the organism was brightest, approximately lemon yellow or light cadmium; it was

[1] Erwin F. Smith, Pseudomonas campestris (Pammel): The Cause of a Brown Rot in Cruciferous Plants. *Centralb. f. Bakt. u. Parasitenk.*, Abt. ii, Bd. iii, pp. 284–291, 408–415, 478–486, Pl. VI. 1897.

dullest on the steamed turnip, where there was also a marked production of the brown pigment. The organism was also grown in fermentation tubes using the various kinds of sugars. It is not an acid or gas producer. A brief summary of characters is given at the end of the paper. The organism is closely related to Wakker's *Bacterium hyacinthi*, from which it differs chiefly in its pathogenic properties. This paper is an important contribution to our knowledge of bacterial diseases of plants. Great care was observed in details of making media, and the manner in which the infection experiments were conducted should be highly commended.

In a second paper on the same subject [1] Dr. Smith deals largely with methods of prevention, giving the result of field studies made in 1897. Nine-tenths of the infections are through water pores. Infections by means of the gnawings of insects were also observed. The disease has been successfully inoculated into the black mustard, and is common in some places on charlock. No evidence has been obtained to show that it is transmitted by seed. A contaminated soil is the most frequent source of infection. The observations here recorded leave little room to doubt that the organism lives over winter in the soil, that it is often transplanted from contaminated soil to healthy fields in diseased seedlings, and that the preparation of healthy seed beds, *i.e.*, on soil free from this organism, is one of the most important preventive measures. Of course, rotation of crops would also be an effective remedy.

L. H. PAMMEL.

A New Laboratory Manual. — To the many laboratory manuals is added a new one in the field of botany,[2] which is intended to give the student a general view of the subject and at the same time to lay a foundation upon which more advanced studies may be built. The author suggests that the rather extended scope of the book need not prevent its use for briefer courses, since by judicious selection certain parts only may be used where the entire field cannot be covered. One hundred and ninety-one illustrations add to the attractiveness of the book, and in the main they are well selected from good sources. Though the illustration of a laboratory guide is a device for conveying information rather than promoting independent investigation, it is by no means certain that it is a reprehensible practice when, as is

[1] The Black Rot of the Cabbage. *Farmers' Bulletin*, No. 68. U. S. Dep. of Agric., Washington, D. C., Jan. 8, 1898.

[2] C. H. Clark, *A Laboratory Manual in Practical Botany*. New York, American Book Company (1898), 271 pp.

the case in most colleges, a very small percentage only of the students of science are likely ever to have the opportunity to devote their lives to research. T.

A Guide in Vegetable Physiology. — Professor Arthur of Purdue University has issued in pamphlet form an outline for thirty-five laboratory exercises in vegetable physiology,[1] which are intended to guide the student in manipulation while avoiding the provision of information as to the purpose of the experiments or the deductions to be drawn from them.

Digestion of the Albumen of the Date. — M. Leclerc du Sablon, in the *Revue Générale de Botanique* for Nov. 15, 1897, publishes a paper on the digestion of the "albumen" of the date, in which it is shown that not only is this albumen incapable of digesting itself, but that the diastases secreted by the cotyledon, which attack the cellulose, do not penetrate into the albumen, their action appearing only in the region of contact between the cotyledon and the albumen, only the enzyme which leads to the production of fatty acid passing from the cotyledon into the albumen, where it begins the digestion of the fatty reserves.

Experiments with Etiolated Leaves. — In a paper published in No. 107 of the *Revue Générale de Botanique*, Palladine shows that when etiolated leaves free from carbohydrates are placed on the surface of various solutions, saccharose, raffinose, glucose, fructose, maltose, glycerine, galactose, lactose, and dextrine favor the formation in them of chlorophyll, while inulin and tyrosin produce no effect, and mannite, dulcite, asparagine, alcohol, and some other substances either retard or completely prevent the formation of the pigment.

Life History of Ranunculus. — To the *Botanical Gazette* for February, Prof. John M. Coulter contributes an addition to the life history of Ranunculus, embodying the results of the study of a number of research students at the University of Chicago. The results appear to justify the conclusion that while it is comparatively easy to obtain a definite sequence in the development of structures when the facts are few, definite sequences seem to disappear as facts multiply; a conclusion which may be paralleled in nearly or quite all

[1] J. C. Arthur, *Laboratory Exercises in Vegetable Physiology*. Lafayette, Ind., 1897. Kimmell & Herbert.

lines of investigation, and one which speaks strongly against the too frequent custom of basing broad generalizations on isolated and unverified observations.

Food Plants of Scale Insects. — Though sometimes misleading, lists of the host plants of parasitic fungi or of the food plants of vegetable-feeding insects are always helpful when properly used; and a list of the food plants of scale insects, by T. D. A. Cockerel, in volume xix of the *Proceedings of the United States National Museum*, will be acceptable to students of this group. The author states that it is to be understood that the plants given as hosts have been infested in many cases only since they have been cultivated, and suggests that it would be desirable to distinguish in every case between the endogenetic and exogenetic Coccids on a plant, and also between those exogenetic in a state of nature and those only so in cultivation.

Timber Pines. — The timber pines of the Southern United States form the subject of an important contribution from the Division of Forestry of the Department of Agriculture.[1] Though a revised edition of an earlier series of monographs, the present publication appears with almost the value of a new work. In it *Pinus palustris*, *P. heterophylla*, *P. echinata*, *P. tæda*, and *P. glabra* are quite fully considered, from the standpoint of forestry and mechanics, as well as that of botany. To the teacher of economic botany such excellent illustrations as those of Plate VIII, showing the method of "turpentine orcharding in Louisiana," are next in value to an actual field demonstration. T.

New England Botanical Club. — The New England Botanical Club, an association of gentlemen interested in the flora of New England, which holds monthly meetings in Boston and has begun the formation of a New England herbarium, has recently issued a tastefully prepared pamphlet containing its constitution, with a list of its officers and members. Thirty-seven resident and twenty-four non-resident members are enrolled.

Botanical Garden in Dahlem. — The plans for the new botanical garden in Dahlem, near Berlin, the distance of which from the teaching departments of the great Berlin University is lamented by

[1] *The Timber Pines of the Southern United States.* By Charles Mohr, Ph.D. Together with a discussion of the structure of their wood, by Filibert Roth. *Bulletin No. 13* (revised edition), *U. S. Department of Agriculture, Division of Forestry.* Washington, 1897. 176 pp., 27 pl. 4°.

those whose duties confine them more closely to the University, have been quite fully outlined by Dr. Engler and his associates in recent numbers of *Gartenflora*. The concluding article, in the issue for January 15, contains a small map illustrating the general features of the planting and the location of the buildings.

Botanical Notes. — A further contribution to the systematic value of seed anatomy is published by Pritzel, in Heft 3 of *Engler's Botanische Jahrbücher* for 1897, in which the endosperm is discussed in detail for representatives of a considerable number of genera, especially of the Parietales.

The January number of *Forstlich-Naturwissenschaftliche Zeitschrift* contains a description, by Tubeuf, of an aberrant form of our white pine, which is descriptively called *Pinus strobus*, forma *monophylla*.

In the *Berichte der bayerischen botanischen Gesellschaft*, Bd. v, 1897, Andreas Allescher describes a considerable number of new "fungi imperfecti," which, although the types are of Bavarian collection, in many cases occur on hosts that grow also in the United States, so that students of this class of form species need to make note of them.

The double root cap of Tropæolum, described by Flahault in 1878, forms the subject of a communication to the French Academy by M. Brunotte, published in the *Comptes Rendus* of January 17. It is held that the supernumerary sheath originates from the proliferation of the cells of the suspensor.

The study of the hibernacula of plants has received an important extension in an examination of the reproductive organs of a number of species of Pteridophytes and Phanerogams, the results of which are published by Mr. Chamberlain in the *Botanical Gazette* for February, under the title "Winter Characters of Certain Sporangia."

A careful study of the ecological phases of a Scandinavian sand flora is contributed by Erikson to the botanical section of volume xxii of the *Transactions of the Royal Swedish Academy*.

The *Annals of Scottish Natural History* for January contains an article on the flora of Tiree, by Macvicar, and one on the topographical botany of Scotland, by Professor Trail, as an addition to the well-known *Topographical Botany* of the late H. C. Watson.

Professor Spegazzini contributes to the fifth volume of the *Anales del Museo Nacional de Buenos Aires*, for 1896–97, just received, a paper on Fuegian plants collected in 1882, in which eighteen species and one variety — all Phanerogams — are described as new. Five of the species are figured.

Students of South American botany will be interested in the Xyrideæ and Burmanniaceæ (by Malme) and Oxalidaceæ (by Frederikson) of Regnell's first expedition, contained in volume xxii of the *Transactions of the Royal Swedish Academy* of Stockholm.

The occurrence of fossil remains of Brasenia in Russia and Denmark forms the subject of a paper by Gunnar Andersson in the botanical section of the appendix to volume xxii of the *Transactions of the Royal Swedish Academy* of Stockholm, issued in 1897. Two plates illustrate the structure of recent and fossil specimens, the former from Japan and the United States.

Dr. Ernst Huth, whose death in August last cut short a promising botanical career, had prepared a paper on the Ranunculaceæ of Japan, with especial reference to the species collected by Father Faurie between 1885 and 1896, which is published in the *Bulletin of the Boissier Herbarium* for December, 1897.

The Bavarian Botanical Society, which has its home in Munich, is publishing in its *Berichte* a preliminary flora of Bavaria, in which full ordinal descriptions, keys to genera, full generic descriptions, keys to species in the larger genera, and detailed specific descriptions are given. In many cases the geographical range of the several species of a genus is indicated on reduced maps of the country, which, for the more ready contrast of related species, are printed in pairs in the text. Thus far, the flora reaches Dentaria, in the Cruciferæ.

A somewhat similarly treated flora of the neighborhood of Nuremberg and Erlangen, by A. F. Schwarz, which is being issued in parts by the Natural History Society of Nuremberg, reaches the Rutaceæ, in the tenth volume of the *Abhandlungen* of the Society.

Acalypha virginica, a common North American plant which has become established in Italy, forms the subject of a note by Traverso in *Malpighia* for 1897. It appears that in the vicinity of Pavia, in addition to this species, *Azolla caroliniana*, *Elodea canadensis*, *Commelina virginica*, *Oxybaphus nyctagineus*, and *Solidago serotina*, all pertaining to our flora, have rather recently become established.

Euphrasia canadensis, a supposed new species from the vicinity of Quebec, is described and figured by Frederick Townsend in the *Journal of Botany* for January.

Frederick N. Williams publishes in the January number of the *Journal of Botany* a short article on primary characters in Cerastium, and characterizes in accordance with his views Dichodon, Strephodon, and Orthodon as subgenera.

Mr. C. A. Purpus, who for some time has been active in introducing the choicer species of our Western and Pacific coast vegetation into European gardens, contributes to the *Mitteilungen der Deutschen Dendrologischen Gesellschaft* for 1897 an account of his travels in the southern Sierras of California and the Argus and Madurango ranges.

Eriogonum, one of the more puzzling genera of Apetalæ, is enriched by the addition of twenty-two new species, in a paper by Dr. Small, published in the *Bulletin of the Torrey Botanical Club* for January. In the same article, *Oxytheca parishii* Parry is made the type of a new genus, Acanthoscyphus.

The tree opuntias of the United States form the subject of an interesting short article in the February number of the *Botanical Gazette*, by Professor Toumey, whose opportunities for the study and cultivation of cacti, in Arizona, are unrivaled.

A paper on some biographical difficulties in botany, — some of which apparently might be escaped by carrying the application of the principle of priority to Tournefort's work, instead of stopping with the species Plantarum of Linnæus — read before the Botanical Society of America in Toronto last summer, by Prof. E. L. Greene, has been reprinted from volume iv of the *Catholic University Bulletin*, of Washington.

M. Cardot, in the *Bulletin de la Société d'Histoire Naturelle d'Autun* for 1897, publishes a Répertoire Sphagnologique, an alphabetical catalogue of all known species and varieties of Sphagnum, with indication of synonymy, bibliography, and geographical distribution. The pamphlet, which is separately paged, contains 200 pages, octavo.

The Botanical laboratory of the University of Siena has begun the publication of a new journal,[1] the first fascicle of which, for January, 1898, contains a report on the botanical garden and museum for the scholastic year 1896–97, and a number of scientific papers, chiefly on fungi, — a group with which Italian botanists are very largely occupied.

PALEONTOLOGY.

Pleistocene Flora. — For a number of years the Pleistocene flora of Canada has formed the subject of special investigation, chiefly by Sir Wm. Dawson and Professor Penhallow, of Montreal, and Prof.

[1] *Bull. lab. bot. R. Univ. Siena.* Redatto del Dott. Fl. Tassi.

A. P. Coleman, of Toronto. The results reached were of such interest and scientific importance that the British Association at its last meeting at Toronto appointed a special committee, consisting of Sir J. W. Dawson, chairman, Prof. A. P. Coleman, secretary, Prof. D. P. Penhallow, Dr. H. M. Ami, and Mr. G. W. Lamplugh, "to further investigate the fauna and flora of the Pleistocene beds in Canada," and for this purpose made a grant of £20.

For several months past the work of this committee has been actively prosecuted under the immediate direction of Professor Coleman. The results so far reached afford a valuable extension of our previous knowledge respecting the vegetation of that period, and confirm former conclusions as to climatic conditions.

In his last summary of the Pleistocene flora[1] Professor Penhallow discusses the character of the vegetation observed in deposits of five principal localities, — Moose River, Montreal, Green's Creek and Besserer's Wharf near Ottawa, Scarboro Heights near Toronto, and the Don Valley in the immediate neighborhood of Toronto, from which places sixty-three species of plants have been obtained. All of the plants are found to be identical with existing species. The results of the investigations now in progress will show important additions to this list.

Considered in relation to climate, the deposits of the Don Valley represent a vegetation of a more southern type than that now existing there, such as at present flourishes in the Middle States. In all the other deposits the vegetation represents similar climatic conditions, and is comparable with that which now flourishes in the same or slightly more northern situations. A comparison of the Scarboro and Don beds by Professor Coleman leads to the conclusion that the former were laid down first; hence the inference that in the vicinity of Toronto the vegetation and the climate were at first comparable with what may be found at the present time from the southern shores of Labrador through the region of the Gulf of St. Lawrence and the Province of Quebec; that at a subsequent period the climate became warmer, with the introduction of more southern types of plants, such as the osage orange, and that, finally, another change brought about a partial return to the original conditions, with the development of the climate and flora as at present known.

One of the most interesting features of the material derived from these beds is the very perfect state of preservation in which much of

[1] Contributions to the Pleistocene Flora of Canada. *Trans. R. Soc. Can.*, Ser. 2, 1897. II. iv. 59.

the wood is found. In most cases the wood may be cut with a saw; it softens readily in water, and sections may be cut in the usual manner with as much facility as if taken from an existing tree. In many cases, also, the grain and bark are recognizable, while the interior structure is preserved with great perfection. P.

Polish Palæozoics, by Gürich.[1] — The district described in this memoir is in Southern Poland, mainly in the country between and around Kielce and Opatów. This region has been subjected to considerable oscillation, and the rocks are folded and faulted to a marked degree. The geological section extends from the Cambrian to the top of the Devonian, and the strata reach their greatest development in the Devonian. The Cambrian is represented by a single member, the Silurian by four members, and the Devonian by twenty. The Devonian fauna is especially rich, and represents, together with others, the typical zones of *Rhynchonella caboides*, *Stringocephalus burtini*, and *Goniatites intumescens*, so characteristic of certain faunas and horizons in other parts of the world.

The new genera described comprise Plagiopora, a tabulate coral; Ceratophyllum and Hexagonum, cyathophylloid corals; Spirillopora, a bryozoan; and four genera of ostracoda, Antitomis, Trigonocaris, Polyzygia, and Poliniella.

Interesting studies are made on the amount of crustal oscillation, and the nature of the sediments, whether shore, near shore, off shore, or deep sea. These observations are plotted in curves, on tables of the geological succession for various localities. C. E. B.

[1] Das Palæozoicum Polnischen Mittelgebirge, von Dr. Georg Gürich. *Transactions of the Imperial Mineralogical Society of Russia*, vol. xxx, 1896.

SCIENTIFIC NEWS.

As previously announced in these columns, the Fourth International Congress of Zoology will meet in Cambridge, England, on the 23d of August. Sir W. Flower was elected at the meeting in Leyden to be the president of this Congress, but he has been obliged to resign on account of his health, and in his place the Permanent Committee have chosen the Right Hon. Sir John Lubbock, Bart. We are requested to call attention to the cordial invitation issued by the Reception Committee, which is in part as follows:

"The seat of an ancient University, which counts among its *alumni* distinguished zoologists, from the days of Ray and Willughby to those of Charles Darwin and Francis Balfour, seems to offer a peculiarly fit meeting-place for the Congress on its first visit to the British Islands, and the Reception Committee, including the present representatives of zoological science in Cambridge, hereby offer a cordial welcome to their brethren at home and abroad who may accept this invitation.

"The Reception Committee hope to avail themselves largely of the facilities offered by the several Colleges of Cambridge for the accommodation and entertainment of their visitors, while there is assurance that the more suitable of the public buildings of the University will also be placed at their disposal for the same purposes.

"The International Congress of Physiology is to meet in Cambridge concurrently with that of Zoology, and certain arrangements will be made in common, though there is no intention of uniting the two Congresses — each of which will retain its distinct organization.

"The general arrangements of the Zoological Congress will be made, and from time to time communicated, by the General Committee established at the House of the Zoological Society in London (3, Hanover Square), but the duties of the Reception Committee at Cambridge will be greatly facilitated by the receipt of a reply to this invitation, which they hope may be accepted.

"On the receipt of such an acceptance further details with regard to local arrangements will be duly forwarded. It is hoped that it will be possible to find rooms in the several Colleges for many of the visitors; but it is necessary to point out that the accommodation

afforded within College walls is not suitable for ladies. The Reception Committee will use their best endeavors to find accommodation in lodgings for members who are accompanied by ladies, and it is proposed in due course of time to issue a statement relating to the cost of apartments, railway fares, and other information which will be useful to visitors."

Any zoologist who expects to attend the Congress should address a note to the secretaries of the Reception Committee, The Museums, Cambridge, accepting the invitation, asking for further information in regard to the local arrangements, and stating whether or not he expects to be accompanied by ladies.

Among the recent large gifts which have a scientific interest is one of $1,100,000 by Joseph F. Loubat to the library of Columbia University. The income of this will not be available immediately, as the property is subject to a life annuity of $60,000.

Lafayette College is to rebuild its scientific building, Pardee Hall, the destruction of which was noticed some time ago in these pages.

The Massachusetts Institute of Technology has begun the erection of a new building, one floor of which will be devoted to the biological laboratories, giving them about three times the space that they have in their present cramped quarters. Upon the completion of this building, which is promised in August, the general library of the Institute will be moved into the room now occupied by the biological laboratory.

Pomona College, Pomona, California, is to have a $25,000 science building, the gift of Dr. E. D. Pearsons, of Chicago.

One good appointment is to be placed to the credit of the new U. S. Fish Commissioner, — that of Prof. H. C. Bumpus as scientific director of the station at Woods Holl. During the few years past this aspect of the work of the Fish Commission has steadily degenerated, until last year it was at the lowest ebb. Professor Bumpus brings to the position energy and executive and scientific ability, while the fact that since 1888 he has spent nearly every summer at Woods Holl has given him a familiarity with the locality and the capacities of the station which insures good work. If the Commissioner exercises equally good judgment in his other appointments, he will go far toward disarming criticism.

The circulars for the ninth session of the Biological Laboratory at Cold Spring Harbor, New York, have been issued. Owing to the absence of Professor Conn in Europe, the laboratory this year will be under the direction of Dr. C. B. Davenport, of Harvard, who will be assisted in the instruction by Prof. H. T. Fernald, of State College, Penn., Dr. D. S. Johnson, of Johns Hopkins, Dr. C. P. Sigerfoos, of the University of Minnesota, Prof. W. H. C. Pynchon, of Trinity College, Dr. N. F. Davis, of Bucknell University, Dr. H. R. Linville, of the New York City High School, and Mrs. Davenport. The courses offered this year are: (1) high school zoology, (2) comparative anatomy, (3) invertebrate embryology, (4) cryptogamic botany, (5) phænogamic botany, (6) bacteriology, (7) microscopical methods; while facilities will be afforded those desiring to carry on original research. The laboratory has a good equipment, owns five buildings and a naphtha launch. The tuition is fixed at $20 for one course; additional courses at $5 each. Board costs $4.50 and rooms from $1.50 to $3 per week. Regular class work begins July 6 and continues until August 27. Further information may be obtained from the Director, Dr. C. B. Davenport, Francis Avenue, Cambridge, Mass.

A summer school of biology under the auspices of the University of Illinois will be held at the Illinois Biological Station, on the Illinois River, at Havana, Ill., beginning June 15. The regular session will continue four weeks, but members of classes may prolong their work independently until August 1. The school will be under the general direction of Prof. S. A. Forbes, Dean of the College of Science of the University. An elementary and an advanced course in zoology will be conducted by Prof. Frank Smith and similar courses in botany by Instructor C. F. Hottes. The school will be in the immediate charge of Dr. C. A. Kofoid, superintendent of the Station, who will give his attention to the individual work of advanced students. The Station will be open to a limited number of investigators from June 15 to September 15. The libraries of the State Laboratory of Natural History and of the University and the equipment of the biological laboratories of the University will be available for the school. In order that suitable provision may be made for students and visitors, early application is urged. Final lists of desiderata of literature and apparatus for advanced students and investigators should be sent in before June 1. A fee of $10 per month will be charged. Circulars giving further information will be sent on application to S. A. Forbes, Urbana, Ill.

Prof. Rudolf Leuckart, one of the greatest teachers of zoology the world has known, died at Leipzig, Feb. 7, 1898. He was born at Helmstedt, Braunschweig, Oct. 7, 1823, and received his training in medicine and natural history at the University of Göttingen, where he was largely influenced by the anatomist Prof. Rudolf Wagner, and where, in 1847, in connection with Frey, he prepared the volume on invertebrates in Wagner's *Lehrbuch der Zootomie*. In 1850 he was appointed professor of zoology and comparative anatomy in the University of Giessen, and in 1869 he was called to the chair of zoology at Leipzig. Here his work was more in the line of a teacher than investigator, and no one in recent years has had more influence in training zoologists than he. Among his pupils are to be enumerated Andres, Apstein, Bedot, Berlepsch, Bogandow, Brandt, Bütschli, Burckhardt, Chun, Claus, Fowler, Hatschek, Haswell, Henking, Hurst, Ijima, Korschelt, Kossmann, Kraepelin, de Man, Monticelli, Reichenbach, Salensky, Seeliger, zur Strassen, Sturanay, Tichomirow, Uhlworm, Walther, Weismann, and Zacharias; while of Americans, either by birth or adoption, the following have been his students: Baur, Edwards, Fewkes, Gardiner, C. L. Herrick, Mark, Münsterberg, Murbach, Parker, Patten, Pratt, Stiles, Tyler, Ward, Whitman, and R. R. Wright. For many years Leuckart compiled the record of the literature of the lower invertebrates in the *Archiv für Naturgeschichte*, while his writing upon parasites were numerous and valuable. Later in life, in connection with Chun, he established the elegant series of monographs under the name *Zoologica*, of which twenty-three numbers have so far been issued. Leuckart's greatest generalization was the dismemberment of the Cuverian group of Radiata and the recognition of the Cœlenterata as a distinct group.

The U. S. National Museum has received the collection of fossils and archeological specimens made by the late H. Harris, of Waynesville, Ohio. The fossils number some 13,000 specimens, mostly from the Lower Silurian (Niagara) of Ohio.

Prof. Alfred C. Haddon is planning for a second trip to the regions of Torres Strait. Like his previous expedition, this will be primarily anthropological in character, but biological investigations will also be made. The party will consist of about half a dozen students, and will be fully equipped with the ordinary collecting apparatus and, in addition, with apparatus for psychological investigation and a kinematograph for taking native dances, ceremonies, etc. The expedition will be gone more than a year.

Among the appropriations made by the Berlin Academy of Science are 700 marks to Professor Dahl, of Kiel, for the arrangement of the zoological material collected by him in Ralûm, and 120 marks to Dr. K. Holtermann, in aid of his work upon the fungi of the East Indies.

Mr. W. Whitaker has been elected president of the Geological Society of London.

Recent appointments: Prof. Desider Andyar, director of the gardens in Budapest. — Dr. Otto Appel, assistant for bacteriology in the Hygienic Institute at Würzburg. — Eugen Askenasy, honorary professor of botany in Heidelberg. — R. H. Biffin, demonstrator of botany in the University of Cambridge. — G. L. Bunnell, assistant in zoology in the Sheffield Scientific School of Yale University. — Antonio delle Valle, professor of zoology in the University of Naples. — Ernst Ebermayer, professor of forestry in the University of Munich. — Dr. G. B. Grassi, of Catania, professor of zoology in the University of Rome. — Dr. Hans Hallier, assistant in the Botanical Museum in Munich. — Jiuta Hara, professor of zoology in the Agricultural College at Sapporo, Japan. — Dr. Ludwig Hecke, docent for vegetable pathology in the Agricultural School in Vienna. — Dr. Heim, docent in vegetable pathology in the Agricultural College in Vienna. — Alexander Henckel, of St. Petersburg, assistant in the Botanical Institute in Odessa. — Dr. Karl Holtermann, docent for botany in the University of Berlin. — Dr. Karl Hürtle, professor of physiology in the University of Breslau. — Masamaru Inaba, professor of zoology in the Higher Normal School at Yamaguchi, Japan. — Dr. J. Joly, professor of geology in Trinity College, Dublin. — F. C. Kempson, demonstrator of anatomy in the University of Cambridge. — Dr. O. Krummacher, docent for physiology in the University of Munich. — Dr. Bengt Lidfors, docent for botany in the University of Lund. — Dr. Lustner, of Jena, assistant in the physiological experiment station at Geisenheim. — Dr. Alexander Mágócsy-Dietz, extraordinary professor of botany in the University of Budapest. — Dr. Maguenne, professor of vegetable physiology in the Museum of Natural History of Paris. — Prof. O. Mattirolot, director of the Botanical Museum and Garden at Florence, Italy. — Dr. Franz Mattouschek, of Prague, professor of botanyin the gymnasium at Linz, Austria. — Dr. Lafayette B. Mendel, assistant professor of physiological chemistry in Yale University. — Dr. Mentz, privat docent in physiology in the University of Leipzig. — Dr. Pio Mingazzini, of Rome, professor of zoology, comparative

anatomy, and physiology in the University of Catania, Sicily. — Francesco Saverio Monticelli, professor of zoology, comparative anatomy, and physiology in the University of Modena. — Dr. Joseph Murr, of Linz, professor of botany in the Gymnasium at Trient. — Dr. Asajiro Oka, professor of zoology in the Higher Normal School in Tokyo. — Dr. Polumordinow, docent in histology in the University of Kazan. — Romul Alex Prendel, professor of geology and mineralogy in the University of Odessa. — Dr. J. D. E. Schmeltz, keeper of the Ethnographic Museum at Leiden. — Dr. Alexis E. Smirnow, professor of zoology in the University of Tomsk, Siberia. — W. J. Sollas, professor of geology in the University of Oxford. — Dr. A. Steuer, of Dresden, privat docent in mineralogy in the University of Jena. — Dr. Hermann Triepel, docent for anatomy in the University of Greifswald. — W. G. Van Name, assistant in biology in the Sheffield Scientific School of Yale University. — Rudolf Weber, director of the Forestry Station in Munich. — Dr. Kurt Wolf, docent for bacteriology in the Technical High School in Dresden.

Recent deaths: Edmund J. Baillie, botanist, at Chester, England, aged 47 years. — Georg Berthelin, student of the fossil mollusks of the Paris basin. — Horace W. L. Billington, director of the Botanical Gardens of Old Calabar, Nov. 18, aged 28. — Henry N. Bolander, botanist, at Portland, Oregon, Aug. 28, 1897. — Dr. Hugh Calderwood, demonstrator of anatomy in the University of Edinburgh. — John Finlay, lepidopterist, in London, July 4, 1897. — Oskar Friedrich von Fraas, professor of paleontology in Stuttgart, Nov. 22, aged 73 years. — Dr. E. P. Franz, of London, student of neurology. — Dr. Friedrich Adolf Hoffmann, geologist, in Mexico. — J. B. von Keller, botanist, in Vienna, Nov. 14, 1897. — Dr. Gaetano Licocopoli, assistant professor of botany and assistant in the Botanical Gardens at Naples. — Jean Linden, botanist, in Brussels, Dec. 12, aged 81 years. — The missionary R. Montrouzier, well known as an entomologist and collector, May 16, 1897, in New Caledonia, aged 76 years. — Rev. Charles Samuel Pollock Parish, botanist, Oct. 18, in Somerset, England, aged 75 years. — Dr. Friedrich Oskar Pilling, teacher of botany and author of elementary botanical text-books in Altenburg, Saxony, Nov. 22, aged 73 years. — Dr. Ivan Otto Plekarsky, custodian of the zoological collections of the University of St. Petersburg, aged 30 years. — Heinrich Ribbe, entomologist, at Radebeul, near Dresden, Jan. 19, aged 65 years. — Oskar von Riesenthal, ornithologist, in Berlin, Jan. 21, aged 67 years. — Alexander Thominot, student of reptiles and

fishes, in Paris. — Dr. John Valentin, of the University of Buenos Ayres, while on a geological expedition to Patagonia. — James Windoes, paleontologist, at Chipping Norton, England, aged 58 years. — Morris Young, entomologist, at Paisley, Scotland, aged 76 years. — Count Max Zeppelin, zoologist, in Stuttgart, Dec. 3, aged 41 years. — Gustav Zimmermann, entomologist, at Brüx, Bohemia, Dec. 29, aged 66 years. — Albert Zimmeter, botanist, at Innsbruck, Dec. 15, aged 49 years.

CORRESPONDENCE.

The Mating Habits of Viviparous Fishes. — We are indebted to Professor Eigenmann for the following letter, which is of considerable interest because nothing has been recorded heretofore in regard to the mating habits of the remarkable viviparous fishes of California.

SEATTLE, WASH., Feb. 13, 1897.

MR. CARL H. EIGENMANN:

Dear Sir, — I have just finished reading your article on the "Viviparous Fish of the Pacific Coast," in vol. xii of the *Bulletins of the U. S. Fish Commission*, and was very much interested. I thought some observations of mine a few years ago might interest you, so take the liberty to write to you. About six years ago I was crossing Grant Street bridge (which runs across the shallow mud flats south of the city) in July; the tide was making and the water perfectly clear. I saw a large school of pogies, or perch, *Damalicthys argyrosomus;* their actions were so peculiar that I stopped and called the attention of passers-by to them.

The identification of the fish I am sure of, but can state the year and the season only approximately. The perch were swimming around very leisurely, when two would approach, swimming in the same direction, and when about their length apart would turn on their side and come in contact, still moving ahead slowly. They made apparently no effort to remain together, but after an instant would separate and resume their normal position. I did not observe whether the act was repeated by both, but in one instance I was sure that one of them immediately came in contact with another in the same manner.

I recognized the act as one of copulation, as also did the other observers. Any further information, if it is, that I can furnish I will gladly do so, though I am not posted on the fishes, but have always been an observer of natural objects coming before me.

I remain yours,

P. B. RANDOLPH.

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